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Adkins, Monty and Segretier, Laurent (2015) Skyler and Bliss. In: xCoAx 2015: Proceedings of the Third Conferenc on Computation, Communication, Aesthetics and X. Universidade do Porto, Porto, p. 311. ISBN 978-989-746-066-1

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xCoAx 2015

Proceedings of the third Conference on
Computation, Communication, Aesthetics and X.

**xCoAx 2015: Proceedings of the Third Conference
on Computation, Communication, Aesthetics and X.**

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ISBN

978-989-746-066-1

Technical Supervision

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Special Thanks

William Latham

Supporters and Sponsors

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Faculty of Fine Arts, University of Porto

Università degli Studi di Bergamo

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Fundação para a Ciência e Tecnologia

DST

This project is partially funded by FEDER through the Operational Competitiveness Program – COMPETE – and by national funds through the Foundation for Science and Technology – FCT – in the scope of projects PEst-C/EAT/UI4057/2011 (FCOMP-OI-0124-FEDER-D22700) and PEst-OE/EAT/UI0622/2014.

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Foreword

Welcome to the proceedings of xCoAx 2015, the third edition of the international conference on “Computation, Communication, Aesthetics and X”. Continuing in the tradition of its predecessors, xCoAx 2015 provided a forum for artists, musicians, scientists and researchers to share and explore synergies and intersections in the fields of computation, communication and aesthetics. Operating from the interstices between human creativity and rule-bound computational systems, artists, performers and researchers presented their own exciting new proposals and ways of expressing the unknown or the ‘x’ that underpins each xCoAx event.

This year’s edition was held in Glasgow - a city boasting a long and rich heritage in the arts and sciences - with the Centre for Contemporary Arts (the CCA) acting as the main venue. The conference consisted of paper sessions, a keynote address delivered by pioneering computer artist Professor William Latham (Goldsmiths, University of London), performances and social events, an exhibition spread over two venues; not forgetting the final send off courtesy of the xCoAx algarave at the Glasgow School of Art. The program included 87 participants from 14 countries. We would like to thank them - authors, artists, musicians and performers - and also the panel of reviewers from the scientific committee who worked hard to ensure and maintain the high quality of works accepted to xCoAx.

We would also like to acknowledge the support received from the following institutions without whom there wouldn’t have been a conference: the Creative Futures Institute, the University of the West of Scotland (UWS) - the School of Media, Culture and Society, and the School of Computing and Engineering, the University of Porto, the Portuguese Catholic University, ID+, i2ADS, CITAR, the University of Bergamo, the Centre for Contemporary Arts, Glasgow and the Glasgow School of Art. In addition to this, the support received from an excellent group of volunteers helped make this year’s event a great success.



Papers



xCoAx 2015
Computation
Communication
Aesthetics
and X

Glasgow
Scotland
2015.xCoAx.org

Printed Radicality

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Keywords: print, publishing, fake, library, digitalisation, plagiarism, wikipedia

The static and unchangeable printed page seems to be hardly considered in years 2010s as a key tool for political and radical strategies, as human beings are constantly looking at a few personal screen-based devices, most of them updated in real time. But there are a few cultural elements in traditional media, which are still playing a decisive role in the circulation of culture. Among them the recognition of their aesthetic “forms,” even if digitised in both design and content. The familiarity with those forms is based on metabolised “interfaces” (we’re all culturally “natives” when it comes to radio, tv, and print) that makes them almost invisible, especially when translated for the digital realm, delivering the content in a more direct way. And since we recognise those forms instinctively, we “trust” them, and so we trust their content.

1 Newspaper as (fake) political imaginary

The form of the newspaper is still one of the most recognisable. What we can consider as the modern form of newspapers has only slightly changed since the 19th Century (except for the inclusion of pictures and colours), becoming a daily medium for quite a few generations, establishing itself as an aesthetic standard and a defined cultural object with its specific interface. That's why artists and activists have often used newspapers as an identifiable information environment and a daily object at the same time. From Andy Warhol's "Headlines" series (Donovan 2011), with huge reproductions of particularly dramatic front pages as frozen in time, to "Modern History" series by Sarah Charlesworth (1979), tracking the use of the same picture on different front pages. But a specific conceptual manipulation of newspapers (and the conventional ecosystem surrounding them) has been employed by artists and activists to foster specific ideas. The "fake" newspaper, or accurately reproducing a real newspaper arbitrarily changing its content, has always been able to question the instinctive trust we have in this medium. If making fake copies and freely distributing them in order to attract public's attention (but then revealing themselves as mere advertising flyers) is a remarkably old practice, dating back to the end of 19th century¹, the conscious use of those fakes as a political medium is more recent. In this respect, there are a few effective examples emerging especially in the 1970s. "Il Male" (Sparagna 2000), for example, stemmed during the rise of leftist political movements in Italy, and especially the "Creative Autonomism" student movement in 1977. It conducted a few campaigns through fake journalistic "scoops" (all being simultaneously plausible and surrealistic) rendered in major Italian newspapers layouts and attached next to newsstands, generating sometimes quite harsh reactions and a lot of discussions in the streets. In the same years another two actions (officially anonymous) were accomplished. In 1979 in Poland, a fake of the major propaganda newspaper Trybuna Ludu was distributed during Pope John Paul II (Karol Wojtyla)'s visit to his homeland, sporting the banner headline "Government Resigns, Wojtyla Crowned King." (Sparagna 2000) And in France, in 1977, a fake Le Monde Diplomatique was anonymously distributed to a certain number of subscribers, featuring very satirical comments on the Rote Armee Fraktion's Stammheim Prison bloodbath (Alferj, 1979). Thirty years later an impressive fake newspaper distributed in several thousand copies invaded the streets of New York City, on November 12, 2008: "The New York Times special edition" by The Yes Men in collaboration with Steve Lambert and The Anti-Advertising Agency, and anonymously sponsored.² It was set in the



Fig. 1 Il Male, 1978, fake of "La Repubblica" front-page

¹ "The Most Common Fake Historic Newspaper" <http://www.historicpages.com/lincfake.htm>

² "New York Times special edition | The Yes Men" <http://theyesmen.org/hijinks/newyorktimes>

near future (July 4, 2009), featuring only positive news, briefly plausible after Barack Obama's election as U.S. President. The New York Times layout, fonts and graphic design were painstakingly reproduced (including the usual advertisements, satirically changed as well), so the majority of the public was easily fooled. A large network of volunteers distributed it for free in the city, even in front of the New York Times headquarters, without any legal repercussion. What was embodied here was the public imaginary, the articulated hope this historical event generated, historicised then altogether in a stable and recognisable format, without the daily compromises of major media. The group produced another few fakes, one of them in the form of the International Herald Tribune. Italian artist Paolo Cirio, instead, made a project composed by a web application, a workshop and an action in 2011, called inVeritas. It is centred on Italian newspapers, inviting people to invent their own story that can be composed as a headline sheet with the newspaper logo of choice, through the project's website. Then it's fairly easy to print it out and attach it (during the night) close to local newsstands.³ The use of fake newspapers in political campaigns has proven not to be a thing of the past. The classic strategy of purchasing a full front page ad, designed to look just like the real front page has been used many times. The Liberal Party in British Columbia did it in 2013, disguising the ad as "official" information, and so generating a whole national media case with polarised reactions about the Party ethics and the high risk of misleading the readers.⁴ Even more, in 2011 there was a more direct political newspaper scam, when police identified a network of infringers who had been illegally producing and distributing fake copies of Ziarul de Garda and Timpul, two of Moldova's leading newspapers, trying to manipulate the public opinion ahead of elections by publishing negative articles about the pro-Western ruling coalition.⁵

³ "inVeritas - Paolo Cirio - Contemporary Artist"
<http://www.paolocirio.net/work/inveritas/inveritas.php>

⁴ "Liberals buy front-page newspaper ad touting debate win - British Columbia - CBC News" last modified May 01, 2013, <http://www.cbc.ca/news/canada/british-columbia/story/2013/05/01/bc-liberals-newspaper-ad.html>

Fig. 2 "inVeritas" Paolo Cirio, 2011



⁵ "Fake newspapers' network dismantled in Moldova - World - on B92.net" last modified May 17, 2011, http://www.b92.net/eng/news/world.php?yyyy=2011&mm=05&dd=17&nav_id=74384

2 Plagiarism (from print to digital and vice-versa)

Newspaper fakes incorporate some forms of “plagiarism”, mostly related to misusing a “standardised” visual form. This has been technically feasible since the mechanical reproduction of print, and even more with the lightning-fast speed and accuracy of digital (re)production. But the plagiarism of content is much older, and the very concept of plagiarism dates back to the Roman Empire. It was used for the first time by Roman poet Martial, complaining that another poet was “kidnapping” his verses, so he called him “plagiarius”, which literally means “kidnapper.” These were the verses he used to express his feelings:

*Fama refert nostros te, Fidentine, libellos
non aliter populo quam recitare tuos.
si mea vis dici, gratis tibi carmina mittam:
si dici tua vis, hoc eme, ne mea sint.*

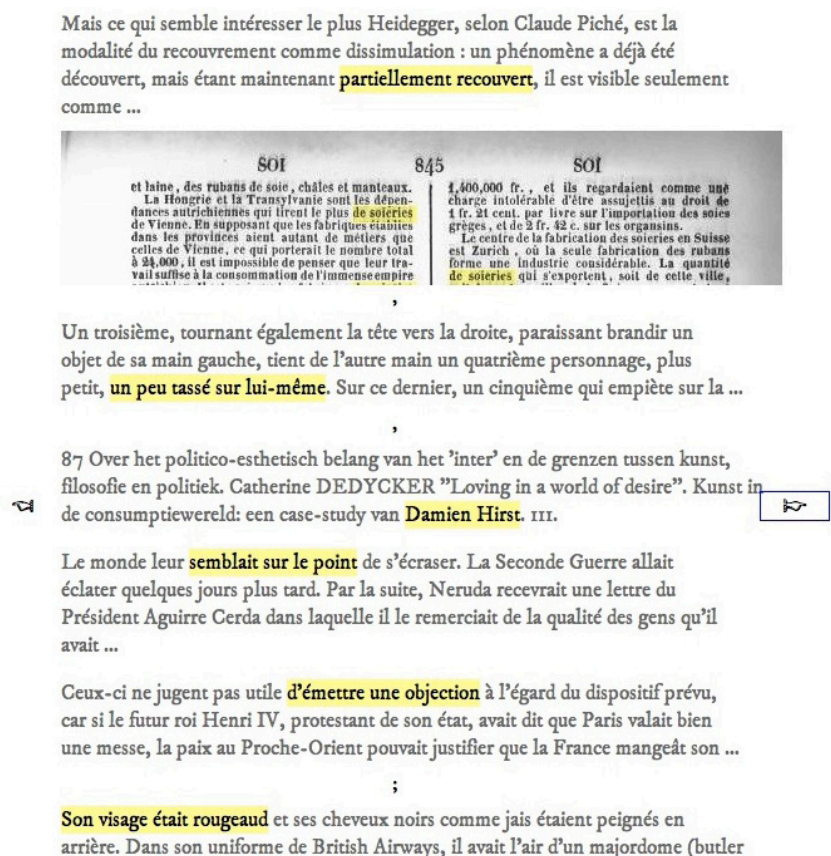
*(Fame has it that you, Fidentinus,
recite my books to the crowd as if none other than your own.
If you're willing that they be called mine, I'll send you the poems for free.
If you want them to be called yours, buy this one, so that they won't be
mine.) (Lynch 2002)*

There are plenty of more or less famous cases of literary plagiarism in history, but only some of them were publicly admitted (like the script of the TV series *Roots*, admittedly plagiarised by his author in some passages from the novel “*The African*,” published nine years before). In contemporaneity, plagiarism seems easier than ever, especially taking advantage from “big data” sophisticated sources like Wikipedia, and so a few critical artworks have been developed consequently. Belgian artist Stéphanie Vilayphiou investigates how free software can deeply question the fixity of the printed page once it's digitised, and how the defensive copyright practices, historically consolidated, can be challenged. In particular she writes various transformative software to create controversial versions of literature classics. Specifically, in her net art piece “*La carte ou le territoire (The map or the territory)*”⁶ she selected a controversial book, Michel Houellebecq's “*The map and the territory*”, which became renown and discussed in France for its evident quotes from Wikipedia, never acknowledged by the author nor by the publisher. She retrieved the book's digitised text and then wrote a software filter which parses it in sentences (or part of it) looking for them in the millions of digitised texts contained in Google Books, eventually finding the same

⁶ “*La carte ou le territoire | Espace Virtuel*” <http://espacevirtuel.jeudepaume.org/la-carte-ou-le-territoire-1834/>

sequence of words in any other books. The results are rendered then in their original typefaces, and the parts matching Houellebecq's book are highlighted in yellow. Visually the book is entirely transformed in a sequential digital collage of quotations (whose original authoritative printed context is still maintained in the background), definitively loosing even the last bit of originality. Vilayphiou ultimately questions originality and authorship through software automatism, turning them into trackable and technically demonstrable collective thinking. Another example of artistic practice deliberately using other people's writings in a specific context is Traumawien's "Ghostwriter"⁷ series. The Viennese group performed a virtual "action" with their own software robots compiling and uploading hundreds of e-books on Amazon.com with text directly stolen from YouTube videos' comments, as if they were abstract dialogues. They have defined it an "auto-cannibalistic" model, and these e-books sport a very classic paperback layout as spontaneous instant books, redirecting the endless flow of comments in a specific form and freezing them in time. This action is obviously re-contextualising the original meanings, setting them in a new scenario and in a new literary form: from personal notes not necessarily relating each other, into a single continuous and sometimes surreal dialogue. What happens in the passage from one medium to another, is that the original spontaneousness and sometimes naïveté of the text once rendered as

Fig. 3 Stéphanie Vilayphiou "La carte ou le territoire" screenshot, 2012



7 "GHOSTWRITERS « TRAUMAWIEN » <http://traumawien.at/prints/ghostwriters>

a book assumes the formal character of the adopted layout. The paradigm of access to “big data” is embedded in practices like the above mentioned, and the software programmer’s vision is the only limit to what kind of results and new (digital and printed) forms can consequently be created.

3 Printing as a risky strategy

In the end of years 2000s there has been a few famous and dramatic cases of sensitive information leaks: Wikileaks and its small galaxy of information-wants-to-be-free “heroes” (Julian Assange, Bradley Manning, Edward Snowden) publishing secret or classified information from anonymous sources, and Aaron Swartz and his brave act of freeing the copyrighted academic knowledge of JSTOR (Nelson 2013) (Swartz committed suicide in 2013). The leaks’ transmission and acquisition have been totally digital, but then traditional media have been deeply involved to make this information “public” (and implicitly to somehow certify the scale of the action with their innate “authority”,) including printed ones, mainly newspapers. At a smaller scale, there are other cases using print as a tool for liberating secret information. Carl Malamud, for example, an activist dealing with the fact that vital parts of US law are secret and that you’re allowed to read them only paying a quite high amount of money, has founded Public.Resource.Org⁸ organisation, which digitises, and eventually re-publishes public domain materials. He has scanned, OCRed and re-published in print, codes like the “Public safety codes of California” or the “District of Columbia Official Code” including in the print a statement that says “being law, any claim about their copyright by the authorities is “null and void.”” Answering the question “why print copies?” Malamud says that the print edition limits distribution with no “side effect of infinite copy” that scares standard and legal people, so making his efforts somehow still acceptable. In this case print is turned into a legally strategic medium of distribution, because of its slow duplication standards, as newspapers have been equally strategic for Wikileaks, being part of a clever tactic that considers the different role and weight of the respective medium, in order to seamlessly accomplish an effective distribution of the content.

⁸ “Public.Resource.org”
<https://public.resource.org/>

⁹ “Google and the world brain
 - Polar Star Films - The most ambitious project ever conceived on the Internet” <http://www.worldbrainthefilm.com>

4 The library, ultimate cultural centre vs. big data repository

“(Libraries) are nerve centres of intellectual energy [...] knowledge is power [...] and that power should be disseminated and not centralised.”
 Robert Darnton, Harvard University library director⁹

The physical library is one of the crucial spaces where the discourse about the new relationships between traditional and digital publishing is taking place. On one side the “global virtual library” is closer than ever with Google investments worth millions of dollars to digitise millions of books, and with plenty of other similar efforts at a different scale, including some remarkably vast, independent and shared. On the other end the physical library’s historically values as meeting and research space for citizens are simultaneously reclaimed and challenged. Funding cuts and innuendos about its obsolescence in the digital era, are dramatically permeating both common sense and institutional policies. Some libraries are reinforcing their role through digital initiatives, like the Toronto Public Library, which launched a Fahrenheit 451-themed alternate reality game, where people were invited to play it in the city through telephone calls with the motto “Join the literary resistance.”¹⁰

And the push on libraries to “reinvent themselves” can effectively be rethought taking the exchange of physical books as a starting point to expand the knowledge in new directions, creating less conventional models for that. So beyond platforms like BookCrossing,¹¹ using a web-based platform and a simple social mechanism to share books in public places, the main question seems to be about which social role the exchange of knowledge can implement. For example there are different efforts in building what could be defined as “spontaneous citizen library”. There are attempts on a small scale like the Little Free Libraries,¹² a few thousands wood boxes scattered around the world where people can take or leave books, or Ourshelves,¹³ a San Francisco lending library open to everyone, with almost 300 members and 3.000 volumes, built around its community, planning to replicate around the city.¹⁴ And if we take into account that Wikipedia has specific templates to add information in its pages about the availability of related content in local libraries,¹⁵ spontaneous social mechanisms connected to a self-managed physical exchange can be easily enabled. These kind of initiatives can question the library as a centralised facility, reconfiguring it as the outcome of a community, opening new possibilities. Teaching how to digitise books, for example, could dramatically expand access, especially to forgotten titles which Google Books won’t include or give access to for different reasons. Then involved people should assume their own responsibility in scanning and sharing, on a personal and independent level in building their own cultural history, preserving (physically) and sharing (digitally) all the knowledge that they think it’s worth, as it has been done with music since the early 2000s.

10 “Take Your Seashells Out of Your Ears! » No Media Kings” <http://nomediakings.org/games/take-your-seashells-out-of-your-ears.html>

11 “Welcome to BookCrossing” <http://www.bookcrossing.com/>

12 “Welcome - Little Free Library” <http://www.littlefreelibrary.org>

13 “Ourshelves” <http://ourshelves.org>

14 “Citizen Libraries Are The New Home For The Printed Word | Co.Exist | ideas + impact” http://www.fastcoexist.com/1681736/citizen-libraries-are-the-new-home-for-the-printed-word?utm_medium=referral&utm_source=pulsenews

15 “Template:Library resources box - Wikipedia, the free encyclopedia” http://en.wikipedia.org/wiki/Template:Library_resources_box

Conclusions

The historical importance of the printed page as a medium has still a great influence in cultural dynamics, and it can be used to trigger innovative and radical processes when approached with the new opportunities offered by digital technologies. Active and critical strategies can be then developed using the combined qualities of those two media. The most effective radical efforts has been historically supported by an innovative use of media and technologies, which has grounded the vision of new social and cultural models. The re-appropriation of public imaginary through printed fakes, the plagiarised use of online content on print, the ability to create social libraries, and the sharing of digitalised content, can structurally redefine the printed medium, turning it into a crucial opportunity to rethink our relationship with knowledge, both in contemporary and historical perspective.

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Understanding Artistic Prototypes Between Activism and Research

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Keywords: prototype, lab, practice-based research, activism.

The paper explores the concept of artistic prototypes to analyse a strand of new media art generated within research or activist contexts. Two key features of a framework for artistic prototypes, openness and fictionality, are explored through the discussion of two artworks which embody a sense of prototypicality. The contingent, situated interpretation of knowledge emerging from creative practice-based research is associated to the instability of prototypes proposed as a paradigmatic object for experimentation.

1 Introduction

Historical and interpretative approaches to new media art have focused on its immaterial, networked nature, and its problematic fitting with traditional museum settings and preservation standards (Dietz 1999; Banovic et al. 2002; Krysa 2006; Paul 2008; Graham & Cook 2010; Graham 2014). Current tendencies in technological development however suggest more hybrid and integrated forms of materiality and immateriality, with digital devices embedded in physical objects or disseminated across the environment, rather than confined to screen-based interfaces (Weiser 1991; Gershenfeld et al. 2004). Such vision towards ubiquitous computing embraces (or questions) ambient technologies that disappear in the background but seamlessly pervade the environment, becoming more human or calmer (Weiser & Brown 1997; Greenfield 2010; Dourish & Bell 2011). New paradigms of understanding account for this shift from a cultural perspective: the notion of post-digital refers to a complete blending between analogue and digital, a dimension where digital technologies are no longer a revolution (Negroponte 1998), but a fully assimilated factor by now treated as a given (Cramer 2014).

A particular strand of new media art is engaging with technology to question patterns of innovation, or tell stories about possible futures. These practices are often generated within research environments, in the context of practice-based research (PbR) or research through design; or from activist and collaborative approaches typical of media-labs, hack-labs and makerspaces.

These works use coding to make physical objects perform in determined ways, and adopt processes close to interaction design. It is actually possible to describe an overlap across art and design, with tendencies like critical and speculative design (CSD) (Dunne 2008) appropriating artistic languages and channels of dissemination, and artists, on the other end, adopting design methods to make artworks. Despite Dunne and Raby's assertion that Critical Design is not art (Dunne & Raby 2007), strong parallels exist with both attempting to inject an element of the critical into the everyday. The main feature that this strand of new media art is borrowing from design is the practice of prototyping or the tendency to present the artwork as a prototype: an invented, innovative device introduced to the public more like a proposal for further development to be used or manipulated, than as a unique, stable piece to be contemplated.

Prototypes are commonplace in research because of the way they afford an analysis of the making process and suggest new fields of exploration. Within activist approaches, they are created to demonstrate how social/political/economic change is possible

and support innovative practices inspired by values such as freedom (of speech, information), equality, sharing and communitarianism, anti-consumerism and environmentalism. This paper compares literature on prototypes with two artworks to explain why it is possible to define them as prototypical, and disclose their relationship with research and activism. Subsequently, it suggests a framework to understand the behavior of artistic prototypes, with the aim to support further work by curators, museum practitioners and theorists in conceptualising and mediating these works to the public.

2 The Prototype: What Is It?

The most common definition of the term prototype relates to the design process: it tangibly manifests an idea to test possibilities and share it with stakeholders (managers, collaborators, perspective users). In fact it *is* an idea. Prototyping has been described as a way of thinking and learning by doing, integrating reflection and evaluation with the practice of making and performing in the real world (Hartmann et al. 2006, p.299). In manufacturing, prototypes are used to assess technical feasibility, aesthetic issues, usability or experience (Visser 2014, p.5); they can address different audiences depending on purpose: to externalise and develop an idea, to promote the project within the organisation, to evaluate user experience, or its potential success on the market. Consequently it can be high or low fidelity and made in different media (Rudd et al. 1996).

Prototyping has been described as crucial to innovation (Schrage 1993; Kelley 2001), especially because of its persuasive power. The material manifestation of an idea can be more convincing than verbal or written accounts, and articulate the complexity of the context in which the new product might become desirable, or the problems it might create. Indeed prototypes are common ways to materialise visions for the future, catalyse creativity (Carleton & Cockayne 2009) and quickly generate new avenues of development (Briscoe & Mulligan 2014; Rosell et al. 2014). Finally, prototypes have a special role within activist paradigms of open and grassroots innovation, when making becomes a pathway for collaboration and to negotiate the value of emerging technologies in bottom-up dimensions of co-creations (Chesbrough 2003; Kera 2001; Kera 2013).

Prototypes are strongly suitable to support cooperation and collaboration within an organisation (Schrage 1993) or through networked communities. They can elicit discussion, facilitate the comparison of different perspectives, and contribute to the articulation and sharing of knowledge around a project. For this

mediating role they have been interpreted as boundary objects (Rhinow et al. 2012; Subrahmanian et al. 2003). Additionally, they are key in participatory design methods to encourage contributions from participants (Bødker & Grønbæk 1991; Greenbaum & Kyng 1991; Vines et al. 2013). These characteristics of prototypes make them ideal instigators in activist processes of change, both proposing viable alternatives to the status quo, and enabling the diffusion of such alternatives through co-creation.

Prototypes can also function as critical artefacts: rather than early versions of products, they are provocative objects able to open up new directions or field of exploration for design; instigate debate; support an investigation on people's values and attitudes (Dunne & Gaver 1997; Bowen 2007; Gaver et al. 2008). Therefore they can be used for advocacy and to subvert a passive acceptance of the status quo. SCD artefacts belong to this category, and are sometimes presented alongside narrative elements and scenarios to depict their imaginary settings.

This brief overview highlighted a variety of ways of describing prototypes and their range of functions: representations, manifestations or mediations of ideas; tools for sharing, collaborating, communicating, testing; embodiments of arguments and visions; props for action or discussion. Such an assemblage of heterogeneous meanings can be useful when compared with existing artworks that present some of the above characteristics. The next section analyses two examples in this light, as a prelude to a more general understanding of artistic prototypes.

3 Artistic Prototypes

3.1 Sentient City Survival Kit

The *Sentient City Survival Kit* (SCSK) by artist and architect Mark Shepard consists of a series of devices conceived to bypass various forms of surveillance in near-future cities dominated by ubiquitous computing. The aim is to question the paradigm of a responsive urban environment disseminated with information systems and to raise awareness on the possible consequences for social and cultural life, privacy and trust (Shepard 2010).

The kit contains four artefacts. The *Serendipitor* is an alternative navigation system opposing the logic of efficiency guaranteed by common navigators, to reintroduce detours, unexpected encounters and serendipity. *Under(a)ware* is a line of underwear able to sense Radio Frequency Identification (RFID) Tag readers and alert the wearer of their presence with a small vibration. The *Ad Hoc Network Travel Mug* creates free networks of communication

hidden to any monitoring system. The *CCD-me-not Umbrella*'s infrared LEDs let the user play and bewilder surveillance cameras.

In a paper presented at the Digital Arts and Culture Conference, Shepard explicitly refers to these artefacts as prototypes and describes them as the main vehicle to disseminate the project in museums, art festivals and public lectures (Shepard 2009, p.5). Additionally, a dedicated website offers DIY tutorials to engage the public in building the kit: these include source code, circuit diagrams and parts list, released under a Creative Commons License. The intention is not just an alignment with an open source attitude, but also that this artistic project be replicated, multiplied and used.

Shepard mentions critical design as a method, and shares with it the goal of generating "discussion around just what kind of future we might want" (ibid. 2009, p.2). The kit however is presented as an artwork, rather than a design project uncovering forthcoming technological trends. As opposed to positions "casting art in a reactionary role vis-à-vis technological development", Shepard wants to explore new roles for the artist "in shaping how we inhabit the near-future Sentient City" (ibid. 2009, p.5). The prototypes are framed as archaeological traces of the future, demanding interpretation and questions about proximal socio-cultural developments "to instigate the process of imagining a future city and its inhabitants through fragments and traces of a society yet to exist" (ibid. 2009, p.5).

Grounded on current orientations of R&D labs in urban computing and ambient informatics, the *SCSK* is rooted in a research framework and, through its prototypes, generates new knowledge (forms of conceptualisations and problematisation of an issue), that finds dissemination through typical academic channels such as lectures and conferences, alongside artistic channels (exhibitions and festivals). Like classic design prototypes, it proposes a set of innovative devices that might be associated with new social practices, but it simultaneously elicits discussion and critical exploration. Finally, thanks to its open source logic, the project presupposes collaboration and, potentially, multiplication, implementation or modification of the prototypes. The activist perspective is rather implicit, but it can be identified with the intent of anticipating change, and inspiring actions of resistance towards imposed technological paradigms (control, surveillance). The next example instead shows a stronger activism take, and a less evident link to research.

3.2 Re:Farm the City

Re:Farm the city is an ongoing project initiated by a collective formed across Barcelona's Hangar Media Lab and Madrid's Medi-alab Prado, with the lead of Hernani Dias. It consists of a set of open source tools (hardware and software) to develop sustainable, small scale urban agriculture. These include farm containers (mobile planters, of various dimension, for indoor or outdoor use), watering systems connected with monitoring systems, compost mixers, a web interface for managing the farm at distance, and bike powered water pumps or generators. The initiative has now reached various cities across the world where new participants have embraced the project, adopting, customising or adding new tools. Part of the tutorials is available to everyone on the blog and wiki. Dias however tends to privilege the formation of small communities built through workshops he runs when invited by artistic institutions, so that a more direct exchange can take place, and the expansion of the project can be more easily documented (Dias 2013).

The tools are prototypes combining sensors, electronics and recycled material aimed at generating new everyday practices and impacting the real world. Their functioning is not always guaranteed; rather they are unstable and open to implementation and customisation according to specific local conditions, including climate, cuisine and biodiversity. This makes of *Re:Farm* an exportable, adaptable model to support local production, conceived to turn much of the city's own recycled trash into a resource (2013, p. *ibid.*).

Similarly to *SCSK*, this work comprises a set of digital devices embodying a proposal for new practices; expects to be shared, appropriated, used and transformed by other contributors; adopts technology to suggest alternative views and critique established ones. Artistic approaches and channels of disseminations are integrated within a process of grassroots innovation supported by typically activist values such as respect for the environment, resistance to consumerist cultures, communitarianism and localism. The project has also been presented through talks and conferences (Calvillo et al. 2010), and its development required combining existing knowledge (from math to biology and the mechanics of fluids) into something new and transferable. This transferability is what differentiates it from more traditional artworks usually expressing the unique talent of the artist. The artefacts created through *Re:farm* are conceived to be as easily replicated as possible.

4 Between Activism and Research

The existence of a strong tie between new media art and research has been recognised in recent literature that emphasises the experimental approach of artist-technologists (Gere 2010) and the way they share similar channels of dissemination and reward with academics, diverging instead from the logics of the gallery and the art market (Scrivener & Clements 2010). The prototypical nature of a significant number of artistic works generated as research however has been neglected in discourses of media art and only mentioned by proponents of PbR in the arts as one of its key physical outcomes. In this context, prototyping has a crucial role because it fits with a cycle of trial, analysis, implementation and evaluation, usually adopted by researchers to combine theory and practice (Winter & Brabazon 2010, p.5; Edmonds & Candy 2010). Here, building artefacts is regarded as the main site of knowledge production, while the identity between maker and researcher is recognised as PbR's defining quality (Coessens et al. 2009; Borgdorff 2011). Accordingly, prototypes are particularly suitable to scenarios where we wish to manifest, visualise and analyse the making process. Because artefact and research development are constantly affecting each other, prototypes are a natural outcome of artistic research. Furthermore, in virtue of their openness to transformation and their unfinished dimension, they are well placed to encourage feedback and elicit responses from users/audiences when the research goals concern aspects of public experience (Muller 2008; Chatting 2014). Finally, prototypes allow hypotheses to be explored and tested in tangible ways, opening up new fields of research or creative possibilities.

The nature of knowledge in artistic research has been at the centre of passionate debates and, in the attempt to establish its position alongside traditional academic standards, redefined as situated, contingent, embodied, experiential and tacit or non-conceptual (Sutherland & Acord 2006; Knowles & Cole 2007; Barrett & Bolt 2010; Borgdorff 2011). These approaches to 'knowing' seen as an action rather than a static entity all share an awareness of the intrinsic dynamism of material and social situations in which artefacts come to exist. We suggest that such an emerging conceptualisation of knowledge comes together with the provisionality and instability typical of prototypes.

The second context where artistic prototypes are thriving can be identified with media-labs and makerspaces. These environments embrace the processual and collaborative dimension of new media art (Graham & Cook 2010, chap.4) by supporting hybrid platforms for activities such as workshops, presentations of work in progress, festivals, conferences or hackathons. Even

though some media-labs, such as MediaLab Prado or Ars Electronica Futurelab, have become key references in the media art scene, most of them develop identities less focused on art in a narrow sense, and more on production and intervention. Social empowerment, environmental issues and participation are generally high on makers' agenda (Yair 2010), and prototyping results as an ideal practice to support these goals. Labs recognise access and engagement with emerging technologies as an essential step to enable citizens in understanding and negotiating otherwise top-down innovation paths (Kera 2013). Specific programmes are devised for the inclusion of marginalised groups such as NEETs, homeless people or women (Frost 2012). Even if deployed in small scale projects, they can demonstrate the potential of alternative approaches and contribute to change accustomed mind-sets or challenge traditional production and distribution systems (Yair 2010, p.3). Prototypes are usually the vehicle of such endeavors, because of their capacity to materialise vision and demonstrate inventive and sustainable possibilities that can be easily built and tested in small communities. Indeed, prototyping resources such as 3D printers, microcontrollers and laser cutters are among the most common items populating fablabs (the area of media-labs devoted to fabrication).

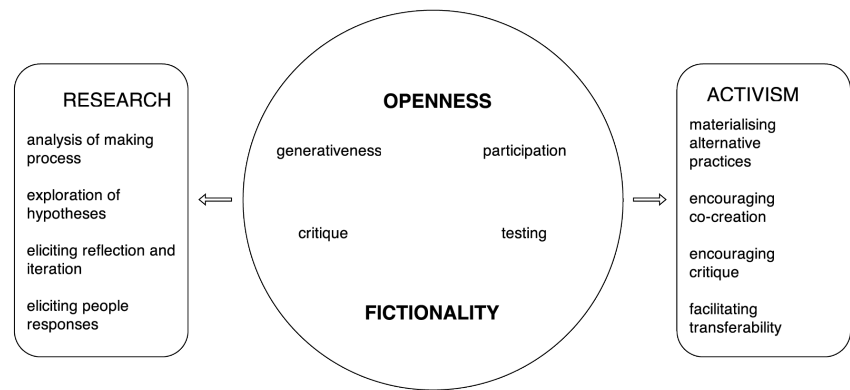
Workshops and hackathons are the most typical event-formats in labs. They engender opportunities to collaboratively and informally work around creative ideas, and generate prototypes thanks to their intense and concentrated structure (Seravalli 2013; Briscoe & Mulligan 2014). The open source ethos and the preference towards recycling that commonly inform media-labs (Frost 2012) is another relevant factor leading to the production of prototypes. Both attitudes imply that objects have an expanded lifecycle and are constantly subject to transformation from a distributed network of users/makers. Prototyping is seen as an agent of change, and connected to an activist mindset that opposes consumerism, encourages exchange, cooperation and sustainable, scalable solutions.

5 A Theoretical Framework

The examples reported demonstrate a range of specific characteristics of artistic prototypes that serve either research or activist purposes. In previous unpublished work we have described a conceptual framework for understanding the behavior of artistic prototypes. 'Openness' and 'fictionality' are identified as their key features and related to research and activism as their main areas of application (Fig.1). The framework also articulates how 'openness' and 'fictionality' support further facets of prototypicality,

namely generativeness, participation, critique and testing. The scope of this paper is however only focusing on a specific part of the framework; in the next paragraphs we will demonstrate that ‘openness’ and ‘fictionality’ are strongly compatible with activist and research functions of prototypical artworks respectively. Beginning by identifying some ways that the examples described embody these facets we will continue by suggesting how a conscious adoption of these aspects of our framework can support artistic prototypes as both kinds of research and modes of activism in the future.

Fig. 1 The artistic prototypes framework.



5.1 Openness

Both *SCSK* and *Re:Farm* imply a potential towards their own expansion, appropriation and modification. This can be understood as a form of openness of the prototype. Prototypes are open because they are unstable, provisional, not definitive, unfixed, prone to transformation and re-definition, situated in a dynamic life-cycle, in between made and un-made. Both this instability and the reliance on external influences to determine its performance relate the openness of prototypes to activist modalities. Openness can be found at different levels. Technological iteration ‘opens’ the prototype to new functionality and consequently new applications. Openness to interpretation not only relates to polysemy and subjectivity (as in Eco’s theorisation of *The Open Work* 1989), but also provokes consideration of the ways prototypes connect to practices, values and cultural systems. These associations between objects and contexts are not established permanently, but evolve through time, so that the same device becomes potentially integrated into very different practices. Finally, multiple and differentiated versions of a prototype can be made, on the basis of shared instructions. This is also associated with a participatory dimension, where interventions are coming from a broad community of local or networked collaborators. Phenomena such

as Open Innovation (Chesbrough 2003) and Open Design (van Abel et al. 2014) are based on a similar principle.

It is notable that the open aspect of prototypical artworks is foregrounded in many activist artworks. This is achieved principally through the production of workshops and through the release of code resources or kits of parts, as described earlier (or in examples such as Loenen 2013; Dentaku 2014). By stressing participation both during an art event (such as an exhibition) and afterwards – as others take forward and develop the work further, artists use the openness of prototypes as catalysts to support a particular vision of participation and a politics of self empowerment: learn to code and gain agency in the (techno-political) world. The activism embodied hitherto in artistic prototypes has the flavor of an alternative techno-utopianism e.g. as described in (Oliver et al. 2011). Code however is not the only site and means of participating in the transformative process around a prototype, as modification and personalisation can also concern other levels of intervention (such as the aesthetic and formal level, or the use and context of adoption). The simple replication and adoption of a prototype as it is released in the public realm is also a way of generating change, by disseminating a new kind of practice or behavior.

We are sympathetic with the political will expressed in such work but note that to achieve its goals requires a very significant proportion of a community to engage, develop and own it. There are some distinct technical devices through which activist-friendly kinds of openness can, we feel, be encouraged. Open source code repositories such as those hosted on Github (Dabbish et al. 2012) provide an appropriate analogy for the success of open, activist, artistic prototypes. We define success here as the degree to which the prototype has become an active agent for change, adopted and adapted by many and put to diverse uses. In open source code repositories contribution comes in two main forms; an addition to the main development strand or a ‘fork’ which effectively splits the development of the code into two diverging directions (which in turn can be subdivided further in the future). There is nothing inherently better or worse about forking or contributing but the latter strengthens and develops the code in tune with a core ethos sometimes explicitly agreed among developers while the former diversifies and pluralises what the project is or can be. Returning to artistic prototypes, we point out that often, little strategy exists for tracking, consolidating and mutually supporting the future iterations of work, all of which might support better its activist aims. Outside of the world of software development we point to a need to manage, identify and coordinate further development of artistic prototypes. Not only will this strengthen and pluralise their development but will also contribute to their

relationship with knowledge and research by allowing for comparisons and cross-referencing of projects in different contexts.

5.2 Fictionality

The fictionality of artistic prototypes also assumes a variety of forms. In our examples *SCSK* explicitly suggests a near future scenario, developed on the basis of current socio-technological tendencies. By contrast *Re:farm* suggests a more subtle (and less futuristic) narrative, letting people imagining how the urban environment might be should the project become commonplace. We propose a very broad definition of ‘fiction’, which includes hypothetical cultural systems and associated values, practices, scenarios, behaviors, and any non-actual but plausible element that can be associated to the way the prototype is used or interpreted.

The fictional layer can be directly provided by the artist through supporting information, documentation and materials; or manifested through ambiguous objects demanding the viewer to imagine possible scenarios to which they might belong. Such strategies support PbR by providing avenues for understanding audiences’ responses to artworks, for pluralizing their message or indeed for helping the artist to develop them in new directions. Fictionality is compatible with research also because of its critical and speculative facets. Artefacts presented as embedded in imagined but plausible situations materialise an alternative world that makes them a prompt for critique, reflection and debate (Dunne & Raby 2010). In critical design the subjects of critique are often innovation, consumer culture, assumptions and ideologies embedded in products. Prototypes support research aims by demonstrating the feasibility or desirability of innovative technologies (Kirby 2009), testing and evaluating their implications on society (Bleecker 2009), or assessing the responses they might elicit in the public (Beaver et al. 2009). Similarly in artistic prototypes fiction becomes an environment where hypotheses can be developed, explored and made tangible. In artistic prototypes fiction and reality are never mutually exclusive, but maintain a strong tie, as the engagement of the viewer is rooted in their complementary relationship. Prototypes’ fictionality is grounded in the artefacts’ material presence and in their scientific or technological background. This is directed at generating in the public a sense that such artefacts can be related and integrated in their everyday lives. Thus, research is enacted through fiction because of an explicit commitment to testing, hypothesis and experimentation on human attitudes and behaviors.

6 Discussion and conclusion

Artistic prototypes are interpreted as a key object emerging from research approaches based on practice and are associated to contingent and transitional definitions of knowledge. Their role in research relates to the way they enable us to investigate the making process, provoke responses in and feedback from the public and provide a tangible environment to trial hypotheses. These potentials are particularly supported by the fictional character of prototypes, especially when involving participants in the study. Openness by contrast is more strongly related to an activist dimension. Its participatory and generative potentialities in fact directly link to grassroots initiatives and to the search for sustainable and ethical alternatives to established patterns of manufacture and distribution.

This distinction is tentative and provisional but intends to support and enrich the vocabulary for further discussion. The concept itself of artistic prototypes is also inherently porous since there are no conclusive and unequivocal criteria to distinguish it from non-artistic prototypes. Rather we point to a ‘family resemblance’ (Wittgenstein 1953) between such works. Aims and contexts in which a project is developed can contribute to the definition of an artistic prototype. Ultimately, it is distinctive of artistic prototypes to be valued regardless of their following developments, whereas other prototypes’ value relate to the expectation of a closure, a resolved version even if that resolution is subsequently undone. Nevertheless, we believe that this framework could be a valuable starting point to identify the emerging concept of the artistic prototype and initiate a debate around its behavior and positioning in contexts where new media art is developing and finding applications beyond traditional artistic environments.

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Interpretation, Representation, Material Properties: Three Arguments About Aesthetic Qualities of Computational Media

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Keywords: Interpretation, representation, materiality,
performativity, aesthetics, computation

Computational visual media presents peculiar aesthetics features that are commonly explored by an instrumental use of technology. This paper introduces three art projects that propose a different perspective on enquiries of digital aesthetics: these works are based in conceptual frameworks, that highlight the technological manifestations of visual devices. The aim of these projects is to brake the immersivity of media representation, in order to reveal the essence of digital image. Each project reflects into specific concepts, here called: interpretation, representation, and material properties. These argumentations take into account the processuality of computation, as well as the materiality of media, as distinctive elements which place the medium identity over its function.

1 Aesthetics of technological expression

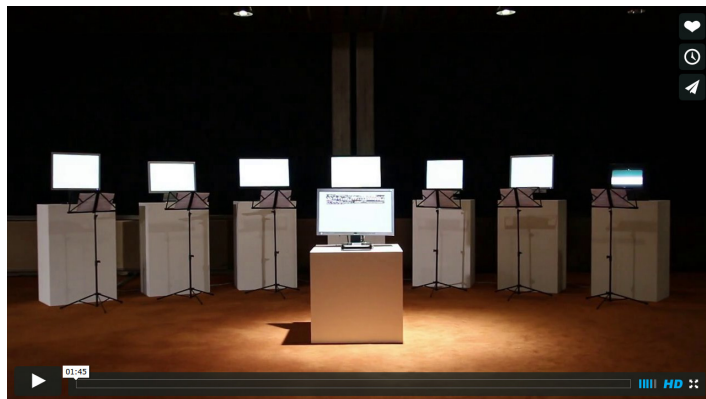
Artistic production is often concerned to an instrumental use of technology, to achieve a purposes that focuses on attractiveness, forgetting or hiding qualities that are specific to a medium. In different cases, the aesthetic qualities of technology are exploited and explored during the production process (Levin 2009). Several theoreticians argue that aesthetic properties of media must be observed in their internal mechanism and behavior (Teranova 2014, Ribas 2014, Broeckmann 2005, Penny 2008, Parisi et al. 2011). Supporting this argument, we should also refer to the approach of Software Art (Cramer 2002, Levin 2009). Therefore, this discussion asks us to entertain a perspective that accounts for the materiality of media (Blanchette 2011, Fuchsberger et al. 2013), considering the role this position can play in terms of aesthetics. This paper presents three art projects made by the author, which propose an approach that deeply focus on media aesthetics, positioning the instrumental role of technology in the background. The main aim of this approach is allow technology to express its own qualities, underlining them into a conceptual frame. Each project described here refers to media qualities in visual aesthetics, formalized in the concepts of: interpretation, representation, and material properties. Interpretation consider computation as performative aspect of digital media. This quality concerns the response of different devices in performing a same set of given instructions. Representation is a historical purpose of visual media, which is reiterated till the latest developments of imaging technologies (Bolter at al. 2002, Huhtamo 2004, Manovich 2009). Representation involves two complementary operations: the image capturing process, and its formalization as visible image. These tasks, see the technical apparatus both as central actor of representation and as main agent of the image ontology itself. Material properties concept underlines the relevance of physicality in digital visual media. The example which focus in this aspect, shows aesthetic potentials that are expressed by the material essence of visual devices.

2 Interpretation: "Arnulf Rainer for Digital Performers"

"Arnulf Rainer for Digital Performers, concert version" is a project that reflects in the aesthetics of visual computational systems, focusing on their interpretation property. Following, it is argued how the performative essence of certain technologies, lead to an emergence of the system identity. This work is an installation presented as a visual concert, which reenact the film "Arnulf

Rainer” made by Peter Kubelka. This film is composed by an alternation of black and white frames, which create a stroboscopic effect. In order to highlight the performative nature of computational media, the installation follows the concert metaphor: several monitors are placed next to each other like an orchestra on a stage. Another monitor with a computer placed in front of them, assumes the role of conductor. The project is technically and conceptually based in a process that happens in software level. In the main computer (conductor) a program analyzes and recreates the original Kubelka composition in real time, in order to extract the color value (black or white) for each frame. In the meaning time, the status of each frame is sent to devices that control the monitors, in order to be reproduced. Thus all the monitors should show the same color at the same time, reenacting the visual score composed by Kubelka. According to the metaphor proposed, the main computer, considered as conductor, is practically instructing the devices (players) to perform the given composition. Like in a concert, each of these systems interprets the commands suggested by the conductor, by means of its own technical qualities.

Fig. 1 Arnulf Rainer for Digital Performers, concert version (<https://vimeo.com/74364647>)



2.1 Interpretation and performativity as systems behaviours

Computational media have performative nature which derives from their processuality (Manovich 2011), and it must be taken into account as founding principle of an aesthetical analysis (Ribas 2014, Broeckmann 2005). Computational agency requires a particular attention toward systems behaviour (Penny 2008), which leads one to consider ethical and political implications, which are embedded in the processual automatism of computational technologies (Terranova 2014, Parisi et al. 2011). Since performativity is considered a key aspect of computational media, we can metaphorically assume its similarities toward music performance. From this perspective we can regard digital code as notation or script, and the whole computational system as a musician who interprets

a music score (Cramer 2002). Interpretation concerns the ability of recreate a certain event, according to the understanding of the event itself and the skills required to perform it. We can take in to account how interpretation works in music: performers must follow a script that informs them what they should play. Certainly, they aims to faithfully represents the original score, but the result of their performance depends on their qualities. In “Arnulf Rainer for Digital Performers” is possible to observe that each monitor respond differently to the instructions sent by the main computer. First of all, during the communication some information get lost. Secondly diverse models of monitors show their own light color and refresh speed. As well as in music, in this project, the system interpretation emerges from the understanding of the score and the technical quality for performing it. However, the metaphors of interpretation as well as performativity are used here as concepts which should not be limited to digital media. It is important to remark that these instances are proper of every technology which acts procedural tasks autonomously, including all devices in the domain of mechanical and analog technologies.

2.2 Structural Film and "Arnulf Rainer" by Peter Kubelka

During the 60s and 70s Experimental Cinema and particularly the Structural Film were movements that criticize the cinematic fiction, applying an artistic research which investigated specificities and aesthetic potentials of the technical apparatus: film, lens, camera, cinematograph, etc. ... (Gidal 1978, Sitney 2002). Structural Film research also included the mechanical and procedural functioning of the machine. The approach proposed by Structural Film was a pioneering approach for the further development of new media art (Chierico 2013), and is still valid as a method for the investigation of media properties. For this reason Structural Film was directly inspirational for the project “Arnulf Rainer for digital performers, concert version”. Kubelka’s work minimized the cinematographic medium, touching upon its technical essence based on light and variation. “Arnulf Rainer” is a film that does not proposes any content: looking to the minimal image composed by monochromatic frames, it is just possible to observe some physical impurities on the film, like dust and scratches. These elements prove fundamental: they expose the identity of the cinematographic medium.

2.3 Differences: a deconstructive method

Interpretation is a pivot point for the conceptual development of “Arnulf Rainer for Digital Performers, concert version”. The whole system interprets the Kubelka’s composition, like orchestra players interpret a given score. In this work is possible to perceive the different ways which players perform, according to various technical factors. Indeed it is possible to notice how monitors behave: communication lacks between the players and the conductor, image refresh speed, and monitor light color, are just some examples of the technical issues and diversities which drive a different interpretation of a same script. However it is important to remark that the image produced by these devices is notably distinct from the one produced by the cinematograph of the Kubelka’s version. Dust and impurities are unavoidable elements of that old technology, as well as actual monitors have flat and cold colour as distinctive elements of their technical apparatus.

3 Representation: “Emerging Aura”

“Emerging Aura” is a work that explores the representational qualities of imaging technologies used in digital photography. Visual representation is a result of a process which includes an input: the subject capture and codification into digital domain, and an output: the image visualization. “Emerging Aura” focuses on the acquisition process of images, to show how this action determines the aesthetic of representation and the identity of the capturing device. This work is formalized as an installation that consists in a video projection mapped on a monitor. The video is composed by a sequence of sixty nine photos of this same monitor, taken from as many different devices, like: web cams, smartphones, cameras, video cameras, laptops, tablets etc. ... All of these pictures were cropped and scaled in order to overlap each other in a same predetermined size. The resolution used for the image scale was found calculating the average between the lower and the higher

Fig. 2 Emerging Aura
(<https://vimeo.com/92341020>)



resolution of the original pictures. This editing permits to use these images as frames of the video. The monitor become the surface of the video projection, where the images are mapped in order to be overlapped with the real monitor.

3.1 "Emerging Aura": aim and method

This project aims to highlight the fictional status of visual representation, showing how the subject depicted in the pictures is differently interpreted by diverse technical apparatus. This process exposes the specificity of the devices used. "Emerging Aura" employs a deconstructive approach toward representation, applying a method based on differences. The immersivity of representation tends to hide the visual qualities of digital image. When the user is involved in the narrativity of representation, images aberrations are slightly perceived, (O'Regan 1992) because the attention moves away from the image itself for focusing into the content. Comparisons between images underline their differences, therefore the denaturation of representation permits to delineate the subjectivity of visual media. Moreover, the projection mapped on the monitor represented by the pictures, offers another evident difference, that emerge by his relation with the original shape of the monitor. The virtuality of representation is overlapped with the object physicality. This attempt to combine them as unique element, at contrary, works as evidence of the real distance between them.

3.2 Specificity as media uniqueness

The name "Emerging Aura" is inspired to the concept of aura by Walter Benjamin (2000). In order to avoid any misunderstanding, must be clarified how this term is used. In short, Benjamin's concept of aura is meant as a supposed value given by the uniqueness of unreproducible art pieces (Benjamin, 2000). However, this project exploits the term aura in different sense: it is considered as uniqueness of media driven representation. This is a conceptual step that wants to underline how every medium conserves its uniqueness in the peculiar aesthetics that emerges from its technical properties. Contents shown by media are obviously characterized by technological qualities of the whole process of recording and reproduction. In "Emerging Aura" there are two conceptual elements that must be highlighted: firstly, the monitor, which is commonly the object that shows the representation, becomes in this context the subject of representation, as well as his physical support. The second important element is the shadow of the devices, which is projected on the monitor since the

shooting moment. The device records a trace of his presence in a space and time, representing itself. Here the aura emerges connecting the monitor representation with the physical uniqueness of the medium: its nature of object.

3.3 A survey on representation

Considering the historical trajectory of visual technologies, in one hand we can notice that representation drove the evolution of devices which attempts to simulate the real, framing contents from the context. During the Renaissance, Leon Battista Alberti theorized the perspective comparing the space of representation to “an open window through which the subject to be painted is seen.” (Bolter & Grusin, 2002) The intent to simulate reality is clear, and it is also obvious how this comparison promises that a potential virtual reality can occur there, to identify this very moment as pivot point for the further progresses in the history of representation. Manovich (2009) and Huhtamo (2004) found that the frame plays an important role, empowering the “window” metaphor, and isolating the fictional space from the context where is placed. For this reason the window of Alberti is seen by Vilem Flusser (1977), as a door where you can enter in a new reality. Representation is a powerful driving force of the development of media, but it is totally disinterested of them. Visual media aims to satisfy the representation hiding themselves. In this way the media fruition is strongly alienated from the complex nature of object. (Bolter & Grusin, 2002) Recent imaging technologies increasingly moves the task of representation from hardware to software domain: algorithms are in charge of reconstruct the image from its capture, in order to supply an attractive quality. This bring to a deep abstraction of the image referent; as found by Hito Steyerl, this process suggests a parallelism with the functioning of representation concept in democratic politics. In other terms, the aesthetical distortion that elapses between the subject and its algorithmic depiction, corresponds to the distortion between the democratic system and its mediated conception. (Jordan 2014) For this reason Steyerl stands for the poor image: in the seams of its aesthetic, are contained signs which manifests the technological mediation of cultural practices. (Steyerl 2012)

4 Material properties: "Unpainted Undrawn"

“Unpainted Undrawn” shows the potential aesthetics which are intrinsic to the materiality of visual digital devices. Technologies of representation are historically bound to the physicality of their support, but the dematerialization of the image, which occurred

with the advent of digital devices, brought the idea that representation does not belongs anymore to the visual support. Instead, the physicality of it is an unavoidable and active element of representation. “Unpainted Undrawn” is a series of works that consist of cracked screens, inserted in classical and modern picture frames. These screens are collected from dismissed devices such as: tablets, ebook readers, smartphones, monitors, and several other kinds of digital devices with broken screens. In LCD screens the array of pixels is contained by a panel of crystal liquids. In case this panel is damaged by crash, the liquids can mix in the matrix, creating unrecoverable spots into the screen. Another common damage of LCD monitors can occurs to the tiny connections that controls the state of each pixel. This kind of damages creates rows or columns of coloured pixels, that remains permanently active into the monitor. Similarly to LCD screens, other imaging technologies have their features in exposing their materiality when damaged. For instance electronic paper, commonly used in e-book readers, is another technology used in “Unpainted Undrawn”. It is here argue that damages of screens, reveals the material essence of digital based images, as well as their potential aesthetics. This is the argument which drove the development of this project. The frame into which these screens are inserted plays a very important role within the concept of this work. First of all, the frame relates to the ancient and romantic stereotype of artwork. Thus the frame’s presence is an ironic attempt to elevate the aesthetics of cracked screens to the status of art. At the same time, the frame recalls the medium of painting, and therefore its materiality, which is explicitly relevant for image creation. In the history of painting, the awareness of materiality emancipated the technique from the status of flat visual representation. In a similar way, the images of these devices are not representations driven by a software, but a physical expression of the screen/medium.

Fig. 3 Untitled from
“Unpainted Undrawn” series



4.1 The materiality of digital media

The word “media” has a communicative connotation, however it is important to underline that when we refer to media, we should also take into account its objectual nature. Conversely, objects have embedded communicational properties that must be taken into account. Starting from this perspective it is important to consider the concept of transparency, formulated by Bolter and Grusin (2002). From their point of view, transparency is the attempt of a medium to hide its objectual identity: devices are designed to be transparent in order to highlight the fiction of representation. As Huhtamo noticed: “The history of the screen fluctuates between the imagination and the world of things. As gateways to displaying and exchanging information, screens are situated in the liminal zone between the material and the immaterial, the real and the virtual”. (Huhtamo 2004) In reference to digital systems, bits are commonly intended as immaterial mathematical units. On the contrary, bits are physical, electrical entities which operate as mathematical units for calculation purposes. Even if this seems obvious, it is very useful to remind ourselves that digital systems cannot exist without the physical constraints of bits and devices. (Blanchette 2011) For this reason materiality is a property which must be taken into account from several points of view, and in every conception, analysis, understanding and design relating to digital media.

4.2 Aesthetics of seams

Structural Film, as already argued, bases its aesthetics on the seams which exposes the technical nature of cinema. One direction of this movement, named Materialist Film (Gidal 1978), was more directly concerned on expressing the materiality of the medium, as previously shown with the example “Arnulf Rainer” by Kubelka. In traditional Japanese ceramics, artifact mending is seen as an aesthetic opportunity, where imperfection becomes a value (Kopplin 2008). This is evident in the Kintsugi method: fractures between pieces of a broken ceramic are filled with precious metals (gold, silver or platinum). In Kintsugi, mending ceramics doesn’t have the sole intent of restoring the object’s functionality, it is an aesthetical choice that shows the physical consistency of the artifact as well as a story of the object. Moreover, the randomness of the fractures determines the artifact’s uniqueness. (Zoran et al. 2013, Ikemiya et al. 2014) Similarly, “Unpainted Undrawn” exploits the occurrence of damage in order to offer an aesthetic formed by object materiality. It is relevant to notice that the images shown in “Unpainted Undrawn”, looks aesthetically and

conceptually near to Glitch Art. In both cases, the images proposed are expression of a technical feature, which emancipate themselves over the contents of representation. However, the aesthetics of error which Glitch Art refers, emerges from the performativity of computational media. (Parisi 2011) Thus, glitch is an error induced by algorithms (intentionally or not) that does not presumes any structural intervention or damage.

5 Conclusion

This paper presented an artistic approach which reflects on aesthetic features of digital visual media. Interpretation, representation and material properties are concepts that illustrates some aesthetic and ontological issues of digital image. Here the intention is to show an artistic method which focuses on the specific properties of media, and that moves their instrumental use to the background. This movement corresponds to an emergence of image technologies, and to a deconstruction of contents, which results in a rupturing of the fiction of representation. Certainly, representation is the key element of this argumentation. Without the intent of representation, any visual medium loses its *raison d'être*, because there are no media which are purely conceived for abstractism. However, it is important to clarify that all the three concepts which are expressed in this text does not correspond to a taxonomy of digital visual media, and they are not separated between them. At the opposite, they are complementary: as stated previously, materiality is an unavoidable aspect of every medium which determines limits and potentials of the image, and if we consider representation as media purpose, interpretation concerns the ability of achieve this purpose. In conclusion, it is necessary to highlight that the projects described here assumes an aesthetic and demonstrative role. In fact, even if they point to the vanishing of representation, they are themselves a representation of concepts. The works development raises an unsolved issue that leads into the vortex of impossible coherence: how can technology truly express itself, when it is an artistic/human intention to define meanings and reasons for its aesthetics? In other words, is it possible to consider these projects as platforms for technological expression, or as appropriations of technological aesthetics? In both cases, the motivation behind this deconstructive approach is a desire to elevate the imaging technologies to the state of art, in order to criticize our mediated representation of the world. An iconoclasm moved by technological realism.

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'Let's Talk Business': Narratives Used in Email and Phone Scams

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Keywords: phone scams, audio installation, interactive storytelling, reverse engineering, activism.

16th century 'face to face' persuasion scams adopted to letters, telephone, fax and Internet with the development of new communication technologies. In many of today's fraud schemes phone numbers play an important role. Various free-to-use on-line tools enable the scammers to hide their identities with fake names, bogus business websites, and VoIP services. These fake businesses or personas can appear more legitimate when connected to a phone number, enabling a faster, more personal contact to the victims. With the typology of a sample probe of 374 emails, commonly used in business proposal scams, the emails were categorized and tested to see how believable the proposals sound once the scammers were contacted by phone. The research can be explored in a 5-channel interactive audio installation called 'Let's talk business' that uncovers which business proposals and scam schemes are commonly used, and how believable the proposals sound once the scammers are called.

1 Introduction

Phone fraud can be described as a ‘fraudulent action carried out over the telephone’ and can be divided into ‘fraud against users by phone companies’ (cramming, slamming), ‘fraud against users by third parties’ (809-scams, dialer programs, telemarketing fraud, caller ID spoofing) ‘fraud against phone companies by users’ (phreaking, dial tapping, cloning) and ‘fraud against users by users’ (vishing, SMS spamming). The different fraudulent actions can also be divided into technical hacking, social hacking, and mixes of both. (Rustad, 2001) The ‘phreaking’ subculture, which is also seen as a forerunner of hacking culture, makes use of both technical and social hacking tactics. By the middle of the 20th century technophiles started exploring the US AT&T network. Listening to the sounds during the in-band signaling connection process, they learned how the network was set up, which metadata was transferred, and were able to reverse engineer the routing of each call. These ‘phone phreaks’ created so called ‘blue-, red-, or rock boxes’ to dial tones and other audio frequencies to manipulate the phone system. With these devices it was possible to make free long distance phone calls, which was illegal and called ‘toll fraud’. They also used social engineering techniques to impersonate operators and other telephone companies. Important representatives of this subculture include John ‘Captain Crunch’ Draper, Steve Jobs or Steve Wozniak, who later founded Apple Computers. In the 80s computer hackers began to use phreaking methods to find telephone numbers of business modems to exploit them. Due to technological advancements, phreaking has lost its popularity, but is still marginally practiced. (Lapsley, 2013)

Whereas ‘phreakers’ mainly focused on technical hacks, curious anti-scam activists called scambaiters adapted more of the social engineering tactics to find methods to safely communicate with scammers, finding out how the scams work in order to warn potential victims. This paper focuses on the ‘user to user fraud’ that is done by email and phone scams. Typically these scams involve storytelling and some sort of social engineering, where the fraudster creates a hyper-realistic ‘too good to be true’ situation for a mark, in order to extract sensitive data and/or money from the victim. (Maggi, 2010) (Mitnick, 2002) These scambaiters host informative websites where scams are reported and host forums where people can discuss suspicious business proposals. There are several forums dedicated to either specific scam genres (e.g. romance scams or rental scams) or used technology (e.g. email scams, phone scams). One of these platforms is ‘Scamcallfighters.com’, a non-profit organization that maintains a user-contributed database of phone numbers that are used in scam attempts. This

organization aims to help people who are under threat of financial loss due to phone scams. On their website they widely publish scam related phone numbers, details of scam incidents and inform about ongoing cybercrime attacks. Confidence tricksters often attack victims who have already been scammed, duping them to pay even more money. The best defense against phone scams is knowledge about this type of scams and a public blacklist.

The artwork 'Let's talk business' is an outcome of an exploration with the aim of understanding in which scam narratives phone numbers are used and how the narratives are extended when the scammers are approached by calling them. Therefore this paper addresses the following issues:

- In Section 2 a sample of scam emails taken from an anti-scam database are categorized into 10 scam types with the focus of the top 5 countries from which the phone numbers originate.
- Section 3 documents the process of calling scammers and the design of the artwork 'Let's talk business'.
- In Section 4 the artwork 'Let's talk business' is contextualized in a historical canon of related telephone artworks.

2 Related works

In 1922 Laszlo Moholy-Nagy wanted to prove that the intellectual approach to the creation of a work of art is in no way inferior to the emotional approach. He called a sign manufacturer and ordered 'three steel panels of diminishing size, covered with white porcelain enamel and bearing a simple geometric design in black, red and yellow'. He didn't provide any sketches, nor did he supervise the execution of his order. (Kac, 1992)

In 1969, the Chicago Museum of Contemporary Art hosted the exhibition 'Art by Telephone'. In the cover text of the catalog, Jan van der Marck explains that the exhibition was planned to record the conceptual art trend. The exhibited artworks should be conceptualized and designed by the artists in their countries. These concepts were transmitted to Chicago and then executed on-site at the museum on their behalf. The telephone was a fitting medium to communicate the instructions between artists and the ones who were entrusted with the production of the artwork. Inspired by Laszlo Moholy-Nagy's experiment, no drawings, blueprints, or written descriptions were allowed. These calls were recorded and made into a vinyl record. The sound recording became the show, as the works were never fabricated. Artists included Jan van der Mack, Richard Artschwager, John Baldessari, Robert H. Cumming, Dick Higgins, SolLeWitt, Bruce Nauman, Wolf Vostell amongst others. (Art by Telephone, 2010)

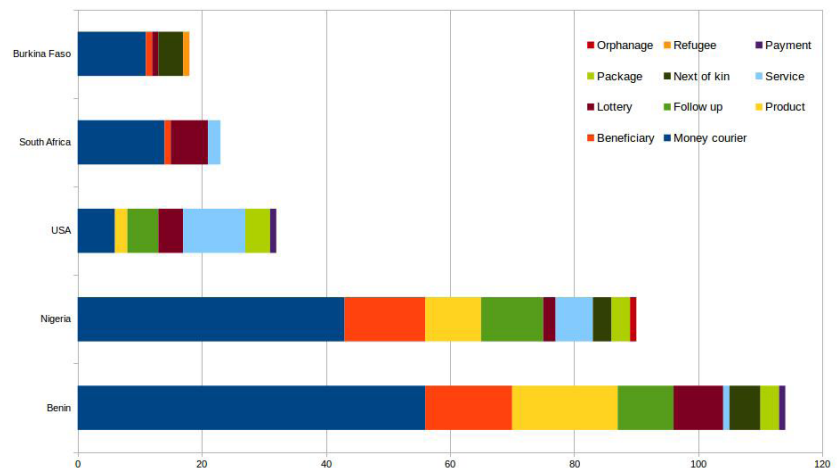
By the 1970s Andy Warhol supposedly had no more substantial involvement during the production of his paintings. The printer Rupert Smith once claimed that even Augusto the security man was doing paintings. Andy was giving a lot of instructions on what the paintings should look like and which colors the printer should use over the telephone. (Colacello, 2014)

In spring 2011 Terri C. Smith curated the exhibition 'It's for you - conceptual art and the telephone' at the Housatonic Museum of Art in Bridgeport, Connecticut. (Smith, 2011) The exhibition brings together artworks that use the telephone as a medium or as a mediator, which fit the category of 'ludicrously simple ideas, but one that allows itself to be complicated and expanded through a myriad of formal and intellectual approaches'. The artworks use language-as-media, democratic impulses through audience participation and broader distribution methods. During the exhibition people performed John Cage's 'Telephones and Birds', where three people perform the work using bird-calls and public service messages from phones.

In early works the telephone has been used to remotely produce artworks by giving instructions. Later, the phone was used to connect artists with strangers or as an interface to access pre-recorded audio messages. Whereas the act of dialing a number, talking and listening remained similar, the technological systems changed from landlines to mobile and VoIP telephony.

In Yoko Ono's piece "It's for you" the artist might call the gallery as part of her Telephone Piece, providing direct contact between artist and the audience. Pietro Pellini's work 'Al Hansen on My Telephone' is an archive of the Fluxus artist Al Hansen. When the phone rings in the gallery, short audio clips of him talking about art, life, the Ultimate Akademie and other topics can be listened to. (Smith, 2011)

Other recent artworks include 'The representative' by Carey Young. In the installation visitors are invited to 'get to know' the call center agent, who normally represents large corporations to the public. The agent was hired by the artist and was scripted to talk about certain topics based on interviews with the agent (Young, 2006). In 2006 the !Mediengruppe Bitnik created the artistic intervention called 'Opera Calling'. They placed cell phones, so called 'audio bugs' within the auditorium of the opera house in Zürich, in order to give the outside public a possibility to access the performances. The performances were also retransmitted to the public through a calling machine that called each person in Zürich individually. (!Mediengruppe Bitnik, 2006) The artwork 'The evidence of things not said' by Afshar, Brunnthaler, Schulze is a prepared public phone booth, where people can listen



3.1 The 'Fund Transfer from Bank' Scam

In this scam attempt the fraudster claims to be (or be related to) a bank representative who offers a high sum of money to be transferred to the victim's account. Normally a small service charge has to be paid for finalizing the paper work and sending the money to the victims account:

I have Paid the fee for your Cheque Draft. But the manager of ECo Bank Benin told me that before the check will get to you that it will expire. [...] Finally, make sure that you reconfirm your Postal address and Direct telephone number to them again to avoid any mistake on the Delivery and Let me repeat again, try to contact them as soon as you receive this mail to avoid any further delay and remember to pay them their Security Keeping fee of \$45 for their immediate action. [...] You can even call the Director of BELLVIEW DIPLOMATIC COURIER COMPANY DR.UGO LORD with this line +229- [REDACTED]

3.2 The 'Beneficiary Payment' Scam

A bank representative contacts the victim because of a beneficiary payment that the victim should receive, mostly without any further details. The victim is asked for personal information and advised to get in touch with the bank:

This is the second time we are notifying you about this said fund. Please as a matter of urgency, you are required to verify the following information and inform us if you are aware or know anything about this. This morning Mr. John T. Kehoe came to the office claiming that you have instructed him to come and receive the payment on your behalf with some representatives.

I have ask them to come back tomorrow as they did not provide any power of an attorney from you which will proof that you thoroughly send them, This was to enable me contact you to verify how genuine this people are to you. We wait for your call on +234- [REDACTED] or email at [REDACTED] and urgent respond to this bank so that you will be giving an immediate response.

3.3 The 'Product-selling' Scam

The victim is contacted by a shop owner or bank clerk who wants to ship a valuable product to the victim, which has already been paid for. A small fee for sending or insuring the item has to be paid in advance:

You are advised to fill this application form and return it back to us as to enable us proceed your ATM VISA CARD. Being desirous of availing the facility of using ATM Visa Debit card, I/We furnish the information below. [...]

3.4 The 'Follow-up' Scam

The follow-up scam addresses former scam victims who fell for an unsolicited offer and paid money to a fraudster. An organization like the Nigerian EFCC, the US FBI, the UN or World Bank claims to compensate a number of scam victims. The victims just have to provide evidence that they lost money and can then get some amount of money refunded:

This is to bring to your notice that we are delegated from the UNITED NATIONS in Central Bank to pay 50 victims from your country who has being Victims of Internet scam .The United Nations has decided to pay you \$8,500,000 USD (Eight Million Five Hundred Thousand Dollars) each. You are listed and approved for this payment as one of the scammed victims to be paid this amount [...]

This email is to all the people that have been scammed or extorted money from [...] We found your email in our list and that is why we are contacting you [...] Contact Pastor Johnson Morris immediately for your Cashier Cheque.

3.5 The 'Lottery Winner' Scam

The recipient of the email supposedly won in a lottery, often run by the Spanish state, El Gordo and La Primitiva. Other lotteries include the Microsoft lottery, where people win by just using Microsoft products or email lotteries where email addresses win a prize. Sometimes, fraudsters claim to represent a multinational corporation that draws an employee lottery and contact the company workers worldwide using the work email addresses.

Please have you received the USD\$2.850,000.00 that your email ID won for you? If this email ID is still active and working feel free to contact Dr.Bankole Williams of EcoBank Plc to claim your winning fund. Contact person: Dr.Bankole, Tel: +229 [REDACTED] Once you contact them they will instruct you how to receive your winning fund. Congratulation once again...

3.6 The 'Service Offer' Scam

In this scam type, scammers offer cheap services e.g. credit loans for very cheap rates and with low interest rates:

We, GLOBAL FINANCIAL SERVICES Credit Union offers loan at a very low interest rate of 3% per year [...] Have you been turned down by your bank? Do you have bad credit? Do you have unpaid bills? Are you in debt? Do you need to set up a business? Worry no more as we are here to offer you a low interest loan. Do not hesitate to contact us on the telephone, fax and email address below for further clarification(s)

3.7 The 'Next-of-Kin' Scam

The victim is contacted by a bank representative, barrister or lawyer seeking someone to stand in as next-of-kin, in order to inherit a sum of money from a deceased person:

However, it's just my urgent need for foreign partner that made me to contact you for this transaction; I got your contact from the professional data base found in the Internet Yahoo tourist search when I was searching for a foreign reliable partner. [...] I have the opportunity of transferring the left over sum of (\$10.5 Million Dollars) that belongs to late Mr Rudi Harmanto, from Indonesia who died along with his entire family in the Asia Earth Quake (TSUNAMI, DISASTER IN INDONESIA / INDIA. 2004, and since then the fund has been in a suspense account. [...] according to the laws and constitution guiding this banking institution, stated that after the expiration of (10) years, if no body or person comes for the claim as the next of kin, the fund will be channel into national treasury as unclaimed fund. Because of the static of this transaction I want you to stand as the next of kin so that our bank will accord you their recognition and have the fund transfer to your bank account. Hence, I am inviting you for a business deal where this money can be shared between us in the ratio of 50/50. [...]

3.8 The 'Package Found' Scam

In this scam attempt the scammer claims to be a representative from a logistics company or Homeland security official, who contacts the victim because of an undelivered package that was found at an airport freight station. In order to release the box and discuss further steps, one should call a number:

[...] I am writing to you regarding on your abandoned consignment box worth 4.5 million dollars...so kindly reconfirm your full address, Full name, Phone number, and nearest Airport. I wait for your urgent and positive respond. you can call presidency officer MR DAVID BROWN Who is the incharge of releasing the box to me. Call +229 [REDACTED] or email [REDACTED]

3.9 The 'Refugee' Scam

In the refugee scam a young women is seeking a person overseas who can help her as a trustee to transfer money from the family's bank account. Parts of her family died in a plane accident, so she also provides a link to a western news agency, where background information about the tragic story can be read. She is now trapped in a refugee camp where she has limited access to the Internet. To get in contact with her, she shares the cell phone number of a pastor she can trust:

My name is Miss Samira Kipkalya Kones, 23yrs old female and I held from Kenya in East Africa. My father was the former Kenyan road Minister. He and Assistant Minister of Home Affairs Lorna Laboso had been on board the Cessna 210, which was headed to Kericho and crashed in a remote area called Kajong, in western Kenya. [...] After the burial of my father, my stepmother and uncle conspired and sold my father's property to an Italian Expert rate which the shared the money among themselves and live nothing for me. [...] So I decided to run to the refugee camp where I am presently seeking asylum under the United Nations High Commission for the Refugee here in Ouagadougou, Republic of Burkina Faso. One faithful morning, I opened my father's briefcase and found out the documents which he has deposited huge amount of money in one bank in Burkina Faso with my name as the next of kin. [...] I am in search of an honest and reliable person who will help me and stand as my trustee so that I will present him to the Bank for transfer of the money to his bank account overseas. [...] the only person i have now is Rev Pastor. Godwin Emmanuel [REDACTED] (58 10) Please you can get me though Rev Pastor Godwin number Please if you call him tell him that you want to speak with me he will send for me in the hostel, Kisses and warmest regards

3.10 The 'Orphanage' Scam

The orphanage scam involves NGO's who seek monetary assistance for local orphans or orphanage institutions. By supporting their causes one can help to build schools or libraries and support their free-time activities:

Please join the efforts between Life and Death to change the lives of children in Nigeria by supporting the orphanage call +234 [REDACTED] [REDACTED] [...]

4 The development of 'Let's talk business'

After categorizing the scam narratives we proceeded to call the scammers. Prior to calling scammers, we wanted to know what means were necessary to stay anonymous and safe without leaving a trail that could lead to us. An interview from the 'Area 419' podcast series explained one method for setting up a connection to a scammer. 'Area 419' was a popular radio podcast that aired on a weekly basis between Feb. and Oct. 2010. (Area 419, 2010) The podcast covers background stories of the scambaiting forum 419eater.com; advice on scambaiting, including interviews with scam-activists and audio clips of phone calls with scammers. Podcast #2 includes an interview with a scambaiter called 'SlapHappy', who talks about his experiences with calling scammers. He uses a VoIP service and has a worldwide plan to call any landline for

free. When a scammer doesn't fully trust him in an email conversation, he calls them to build up his trustworthiness. For him it is hard to realize that there is a criminal talking on the phone, trying to persuade him to pay money. Often, the poor connection quality and the scammers' thick accent make a conversation hard to understand. He uses the 'cold-calling' method to call the scammer and improvises during the conversation.

Next a VoIP account was setup under this pseudonym including a worldwide landline-calling package. The Quick Time Player software was used for recording the voices of the scammers. Before calling the scammers we created a fictional persona with name and country of origin. When a connection to a scammer was established, the scammer was informed that the email was received, but not all relevant parts fully understood, so the situation and the next steps should be explained to us once again. Then the scammers had time to explain the situation and how we should proceed further.

The installation consists of five modified SPAM-cans (see Fig.1 [C]) that are normally used to store precooked 'SPiced hAM' produced by the Hormel Foods Corporation. According to Merriam-Websters dictionary, the naming of unwanted mass advertisement as 'Spam' originates from 'the British television series Monty Python's Flying Circus in which chanting of the word Spam overrides the other dialogue'. The sketch premiered in 1970, but it took until the 1990s for mass emails, junk phone calls or text messages sent out by telemarketers to be called 'spam'. (Templeton) While most of the scam emails tend to end up in the SPAM folder, we chose to mediate these stories through physical SPAM-cans.

Contact microphones and audio players are attached to four of the cans, so that visitors can listen to the scammers' different narratives that were recorded. The fifth device has two buttons: one button connects the visitor to a randomly chosen number from a scammers database, the other button disconnects the call. Next to the work is an information board providing instructions for talking to the scammers. With the fifth can we want to provide the visitor with an opportunity to be anonymously connected with an scammer. This is an experience of being nervous about who will answer the phone, trying to understand the narrative, and judging whether one would fall for such an offer or not. By providing instructions to the visitor, we want to pass on some guidelines and open questions that the visitor can ask the scammers. The guidelines include 'Play along to figure out the scam', 'Never tell any personal information' or 'You are talking to criminals – still they are humans! Open questions can help the scammers to tell more about themselves or their schemes; 'Tell me what do we do next?', 'How can I trust you?' or 'Is this operation safe?'. On a wall

next to the pedestal are two clocks indicating 'Local' and 'Nigerian' time (see Fig. 1 [A]). The best placement for the work is on a 50x50x130cm pedestal (see Fig. 1 [B]). Inside the pedestal there is a computer with an Internet connection that enables the anonymous VoIP communication between the visitor and the scammer.

Fig. 1 Setup of the artwork



5 Conclusion

The 'scammed.by' database was found to provide valuable datasets that can be further analyzed for our purposes. It offers possibilities to categorize scam messages by scam type, country or phone carrier, which offers interesting perspectives for further investigations. When calling the phone numbers, we recognized that not all phone numbers seemed to be in use and some phone numbers appeared in several e-mails, even if the narratives or the characters' names were slightly altered. Through this experiment we experienced that the phone conversations were very personal in comparison to the emails: some scammers were very open to explaining their shady businesses, others preferred to use email and keep the phone conversation as brief as possible. Some of the scammers used voice-morphing software to anonymize their natural voices resulting in a disturbing effect. The conversations with the scammers were recorded, and some of the stories were edited and can be listened to through the SPAM-cans in the art installation.

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Digital Sensing: The Multisensory Qualities of Japanese Interactive Art

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Keywords: Interactivity, Digital media, Device Art, Beyond visual, Multisensory experience.

The paper presents examples of digital art in Japan and examines its roots in traditional East Asian philosophy giving the senses a prominent role in perceiving the world and enabling a perfect symbiosis between humans and machines. The research reflects on the expansion of this culturally and traditionally inspired spirituality from its original context in the socio-cultural interpretation of the natural world to contemporary digitally mediated environments. This is accomplished through analysis of digital interactive work by specific artists located in Japan, such as Kumiko Kushiya, Masaki Fujihata and Ryota Kuwakubo.

Introduction

Technological development has a chief influence on the way the world functions and how it is being perceived. Consequently, it has an impact on the way art is produced and plays an invaluable role in the future of art and contemporary cultural debate. The aim of this paper is to demonstrate the role of evolving new technologies, in extending human senses well beyond their traditional definition. It focuses on the nature of multisensory processes in interactive multimodal art and demonstrates an urgent requirement to develop and deploy innovative hybrid methodologies which reflect and come to terms with innovation, hybridity and complexity of the artworks in question. Walter Benjamin notes that human sense perception

“changes with humanity’s entire mode of existence. The manner in which human sense perception is organised, the medium in which it is accomplished, is determined not only by nature but by historical circumstances as well” (Benjamin 1936).

Today, the media are both concerned with engaging with the array of human senses to the extent that they are largely based on the very concept of sensory language. While technology is by no means the only factor influencing patterns of perception, its specific application leads to the reorganisation of our sensory perception and draws one’s attention to the sensual reception of digital interactive art. As a result of various techniques used by artists, works of digital art communicate via different senses and represent a range of different embodied experiences. Consequently, it is urgent to abandon visual determinism in the era of multimodal art created within it, taking into account not only the sense of vision, but also all the other senses.

Sensory research

Despite the fact that in the early 1990’s the focus of cultural studies shifted towards an anthropology of the senses, this area of social debate has still not taken into account the technological and scientific circumstances of artistic creativity. This reaction to the much vaunted “visual turn” aimed to transfer the foci of social sciences to more sensually versatile spheres. Among others, Classen and Howes assert that every society has its own sensory codes and patterns and its individual sensory order is manifested in material culture as artefacts, which accordingly should be examined with an appropriate attention to hybrid forms of art, culture, and media. Referring to McLuhan, “tactility is the

interplay of the senses, rather than isolated contact of skin and object” (1967[64], 335), which is why it should be investigated and treated like one among other human senses. As long as contemporary culture rejects or underestimates the multisensory nature of human perception, the challenge to develop an adequate theoretical framework which can come to terms with technologically focused media art and culture is almost insurmountable.

The subject of multisensory experiences has been considered in an approach akin to cultural anthropology. Constance Classen scrutinises sensory perception as a cultural, as well as a physical act, noticing that tactile sensations, similar to any other occurrences of our sensory nature convey cultural values on top of purely physical attributes. In fact, the world is perceived through the senses, and sensory perception is mediated by the cultural construction (1997). Furthermore, Karen Cham (2009) states that aesthetic value is culturally coded. Accordingly, since perception is traditionally connected with human evolution, the fact that present-day culture is centred on sensing and perceiving reality through a range of equally important senses cannot, and indeed should not be ignored. This, in consequence, can induce alternative methods of dealing with sensory perception of digital art within the visual or alternatively multisensory\digital culture theory. In interaction, the physical engagement and a certain sensation become involved in action. In the era of digital culture we now inhabit, the hierarchy of the senses shifts and auditory or tactile experiences are becoming equally important as sight in the process of communication, connectivity or perception. As Marshall McLuhan stated nearly 50 years ago: “we had extended our bodies in space” (1964, 3). Taking this into account one can clearly see the effects of this expanded force of perception in today’s world, not only in novel military applications, but also in everyday devices such as vibrating mobile phones, e-books, among other tangible tools; or distinct examples from the world of art, such as *Tenori-On* by Toshio Iwai, or *Bitman* by Ryota Kuwakubo. Nonetheless, clear boundaries between individual senses are blurring into one sensory and versatile experience.

Human perception embodies a fast and constantly active processing of multiple present sensory modalities. For many years psychologists have undertaken exhaustive research in this area (Gregory 1970, 1974; Gibson 1966, 1972); however our knowledge of the significance of new means of science on sensual perception of art is still to be vastly expanded. In this context Laura Marks considers sensual experience and multi-sensory perception in compilation of essays, focusing on the notion of ‘haptic visuality’ in films and video works. Other works reflecting on sensual research oscillate in the historical and anthropological scope of

art (Classen 1993, 1994, 2005). Further works elaborating on sensoriality, in relation to various human senses are being conducted in other areas of applied research, such as film study and visual anthropology (Grimshaw, Ravetz, 2005). The matter of sensual perception has also been an issue for the sociology of the senses as it has been initially proposed by Georg Simmel (1924; 1997). In his essay *Sociology of the senses*, Simmel not only argues about the meaning of sensory perception and its influence on social life and human coexistence, but also about its enormous influence on human interaction. Intellectuals, as for example the psychologist Gibson who worked on the ecological theory of perception (Gibson, 1966, 1979), tried to question the body and mind dualism by treating the body as not only a source of experience but of knowledge as well (See Lera Boroditsky and Michael Ramscar research, 2002). Therefore the paradigm of this embodiment designates an integration of body and mind. Consequently the notion of embodiment, to some extent, changed the approach to body and mind duality. Many contemporary theoreticians try to challenge the domination of the sense of vision; as David Howes calls it “the hegemony of vision in WESTERN CULTURE” (2003, *Foretaste* XII). Furthermore, he continues, that “this dominance is primarily due to the association of sight with both scientific rationalism and capitalist display and to the expansion of the visual field by means of technologies of observation and reproduction” (Ibid.). While the text focuses on analyses the multisensory experience, it also contributes to the debate on sensual anthropology in investigating the means of perception in the field of interactive installation art. Although for many centuries the sense of sight has continually been favoured, the importance and significance of other senses is surely undoubted. Furthermore, apart from the fact that human perception is based on the multisensory experience, where all the senses play an equally important role, sensory perception remains a vital element of all aesthetic experiences (DeWitt H. Parker 2004, Hekkert 2006). Accordingly, most of the human knowledge has its beginning in the sensual realm. In other words, one could say that every experience starts from the senses, as the sensory organs serve as receptors through which human beings are able to know and feel the external world.

Interactive Art in Japan

As the ‘Device Art’ movement originated in the land of the rising sun, this paper focuses exclusively on Japanese artists. The presence of the Japanese artists related to the new media scene has been evident since the growth of the digital media environment. Major international festivals in Europe, the most established being

Ars Electronica in Linz, Austria or SIGGRAPH organised across United States and Asia, are the main events bringing together digital media artists and theorists from the Western, as well as the Eastern corners of the world. The potential of art created in an Asian context is acknowledged in works by various new media art scholars, such as Lev Manovich (2003), Marshall McLuhan (1998), or Ryszard Kluszczyński (2010). While Manovich observes that Japan has a strong voice in digital media debate, McLuhan refers to the Japanese approach to technology inspired by Zen Buddhism, and Kluszczyński elaborates on an instrument strategy, relating it to 'Device Art'. Accordingly, the names of artists, such as Toshio Iwai or Masaki Fujihata are internationally renowned and recognized also outside Japan. Paradoxically, media art discourse reflects almost exclusively on the Western perspective. There has been relatively little theoretical debate, with literature in the field, limited to several names and writings. As such, one of the most prominent voices in the discourse belongs to Machiko Kusahara (2001), Japanese artist and new media art curator, philosopher Hiroshi Yoshioka (1997), Tomoe Moriyama (2006), or Mauro Arrighi (2011). In short, Kusahara introduced the notion of 'Device Art' to the international art world, Yoshioka comments on the concept of media art in the West and Japan, Moriyama shares her perspective on Japanese media art scene, and Arrighi contributes to a debate on Japanese media art and animism.

This study sets out to examine the interface between digital creativity and human sensory features enacted in interactive artworks in this culturally specific context. The following section provides a brief overview of relevant Japanese ritual and spiritual belief, making reference to Japanese thinkers such as Machiko Kusahara and Tomoe Moriyama among others, in order to demonstrate the significant impact of such perspectives on a potential aesthetic reading of digital media art from and in East Asia and Japan in particular.

Tradition

Outlining the background for artistic practices adopting technology and interactive interfaces, and considering their historical background, must acknowledge the unique character of Japanese philosophical thought. Japanese culture with its foundation in a broader East Asian philosophical tradition, giving priority to a monism of body and mind connected with Zen Buddhism and Shinto ideology, fully recognises the importance of the senses in engaging with and perceiving the world. Eastern philosophy implies that between the subjects and the object, as well as mind and body, exists a relationship which induces harmony, and the

human being is treated as a complete organism, unified in mind and body. By means of interactive technology certain aspects of art have gone through a transformation. To name but a few shifts: new tools have been developed, creative collaborations have brought together art and technology. Artists and engineers in Japan often team up with major electronics companies like Canon and use their funding to implement their prototypes. Despite this modern industrial and commercial setting the influence of Shinto on current Japanese art is clear and is confirmed by artists and intellectuals who declare their inspiration deriving from the body of Japanese traditions comprising Shinto belief. Academics such as Moriyama, Kusahara, or Yoshioka stress this notion in their writings concerning contemporary research in art (Moriyama 2006, Kusahara 2001, Yoshioka 1997). Shinto belief has its foundation in the ancient heritage. This tradition of Japan asserts the “existence of spiritual life in objects or natural phenomena called *mi* (the god) and *tama* (the spirit)” (Kitano 2006, 1). Many theoreticians of contemporary art in Japan refer to Shintoism as a major influence on Japanese sensibility (Arrghi 2011, Kitano 2006, and more tentatively Kusahara 2013). This applies to the natural world and inanimate objects and devices which are after all, at least at a molecular level, made from natural elements and substances, metals, and even plastics which come from hydrocarbons formed from organic materials. This holistic view of life also prevails in the perception of artefacts. Consequently, the majority of Japanese religions eschew notions of dualism and embrace elements of animism (a view that sees spirit in every component of the world, not only human beings). Referring to Kenny KN Chow (2012), I suggest that this culturally distinct and traditionally inspired spirituality is transposed from natural or social environments to a present day technological environment of sophisticated multimedia devices and tools used widely in interactive art and digitally mediated environments. Moreover, in such multimodal environments, interaction enables and promotes multisensory experience and intersects with the fluidity of aesthetic experience. All of the examples discussed refer to physical engagement with an artwork and multisensory experience is often an integral part of artistic creations.

Japanese electronic art and Device Art movement

Technological development has always been a great inspiration for human beings, a factor of progress, and a possibility for new experiences. As McLuhan states: “(o)ur new electric technology that extends our senses and nerves in a global embrace has

large implications for the future of language” (McLuhan 1967, 80). In Japan, extensive research on novel technologies and their creative use has among other things resulted in the notion of ‘Device Art’. Hiroo Iwata, engineer and artist initiated Device Art Project in 2004. The idea for the title of the project ‘Device Art’ derived from Iwata’s research activities and blending media art and interactive technologies. The name itself was inspired by Ryota Kuwakubo – discussed below – who once called himself a device artist. ‘Device Art’ has evolved into a new artistic movement at the leading edge of cultural and creative thought in Japan and elsewhere. Its principal characteristics indicate the use of mechatronic devices, new materials and the convergence of innovative technologies, and new ideas in art and design. Artists using everyday components assemble them together with the most recent technologies creating artworks in the form of devices (Kusahara 2008). The concept of ‘Device Art’ is conceived as a modern take on traditional Japanese culture. In line with the critical perspective offered by Kusahara (2008) and Arrghi (2011), the above concept reconsiders relationships between science, technology and art, taking into account historical as well as contemporary perspectives. As such, this form of media art combines art and technology with popular culture, design and playfulness. An open minded, ludic approach to creativity allows these artists to engage with developments in new technology and the possibilities given by new materials as well as acceptance of the very fluid border, or rather lack of it, blends amusement, art, technology, design and popular culture. As we will see in the analysis of work by Ryota Kuwakubo this approach is well developed in Japanese art. Furthermore, Mauro Arrighi has taken a similar stance. The artist and researcher argues that the religious basis present in Japanese culture are an essential element which underpins the development and popularisation of new media art in its specific forms of hybrid art and Device Art in Japan (2011). Theoreticians, such as Mariyama (2006) and Kusahara (2001) among others, repeatedly refer to the historical foundations on which their work is built, including ancient religious beliefs, folk culture and linguistic structure, as a significant determinant of the characteristic approach these artists have developed.

While some of the artists use new technologies as tools assisting in their project design, for others the new technology itself is a new medium carrying aesthetic values and enriches participants’ experience. Nevertheless, what all of them share is that they represent a current of digital art which routinely deploys multimodal technological devices. All of the works presented here serve as practical examples of the potential for embodied experience and multisensory engagement with an artwork. They

illustrate particular aspects of interactive artwork, such as individual artistic strategies used in their production, the processes involved, modes of participatory engagement, and the potential avenues and opportunities they present for the bodily experience.

Sensory engagement in interaction

Each of the works further discussed in this paper demonstrate a variety of applications and critical standpoints. Yet, they all constitute the extensive array of artistic representations which in their aesthetic perspective take into account human senses in art perception. The range of artists presented in this paper ranges from those who started experimenting with technological devices in the early 80s – like Masaki Fujihata, to those who are specifically focused on a particular sensory feature – the sense of touch – like Kumiko Kushiya, to Ryota Kuwakubo, for whom multimodality of an object determines spectators' or users' multi-sensory experience, and who exemplifies the 'Device Art' movement. All of these artists challenge the classic artist-artwork-audience relationship and are part of the notion of a paradigm shift from the art object as something to be observed or hung on a wall to something to engage with directly through multi-sensory experience and aspects of embodiment. It is also appropriate to characterise two different sides of the bodily engagement: the body, as a foundation of immersive experiences and processes of cognitive interpretation of this interaction and immersion (Siemanowski 2010).

Ryota Kuwakubo

is a digital artist and a pioneer of Device Art movement. At the beginning of his career he had been working on electronic toys. The artist's initial fascination was chiefly related to actuators and sensors. The earliest works that he created were not considered art objects, but rather electronic devices and games. Throughout the years his creative explorations have led to projects which have more critical and questioning character, but nevertheless remain grounded in the basic concepts of 'Device Art'. The work examined here, *Nicodama* (2009) is an interface in a form of two half spheres, resembling hyper-realistic eyeballs. The participant is invited to lift the 'eyeballs' and place them freely in the space. The only limitation in order for the work to function is that both small hand held devices need to be arranged in a straight line – just like ordinary eyes.



Fig. 1 Ryota Kuwakubo, *Nicodama*, 2009, Courtesy of the artist

The work is comprised of a small transceiver based on an infrared principle. On account of a magnetic mechanism installed at the back of the work, *Nicodama* can be aligned anywhere in the

space. To interact with the artwork the devices need to be held and actuated accordingly by the participant, giving the user control over an animated creature, and enabling physical engagement. In the text accompanying the Device Art exhibition the artist refers to Japan's historical past and that people

“felt [that] each of the objects around them had a spirit, and treated them with respect and care. Today we share a more objective and scientific approach in seeing things. While there is no doubt that it is important to maintain this attitude, the capacity for empathy is equally important” (Kuwakubo 2009).

The blinking pair of ‘eyes’ reacts to the participant’s engagement and the work can only operate and indeed exist fully through this physical interaction. This artwork, along with some other works by Kuwakubo have been developed and made available as a commercial product, proving to be one of many examples of blurred boundaries between art and entertainment in Japanese culture. Production of gadgets and toys by artists is a common practice in Japan (Kusahara 2006). This is a two-way process including those digital devices as exhibits shown within art galleries as well as being mass produced by large companies and exhibited during art fairs or in commercial spaces. When interviewed about his work Kuwakubo declared that multisensory experience of the recipient serves as one of his inspirations, whether the work deploys complex software or simple manual mechanism (Kuwakubo 2013). Throughout his career Kuwakubo’s inspiration and artistic practice have evolved and slowly started to concentrate on the behavioural side of an artwork and the spectator’s daily relationship with electronic devices. A continuing concern with how people react to innovations in technology is what often motivates his creations. The artist is interested in the whole bodily experience and multimodality of it; by his reckoning, no aesthetic experience can be removed from its multisensory aspect. The experiences being provided by technologically aided artworks lie at the core of his interest in establishing communications between the people and machines. This physical engagement in order to complete the artwork is at the core of the concept.

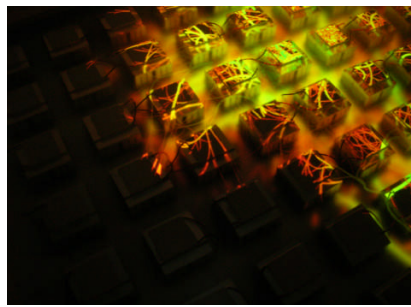
Kumiko Kushiyama

is another example of an artist who combines an interest in the human body with technologically aided objects and machines. Her engagement encapsulates all stages of creative development, from coming up with ideas to designing and engineering completed, leading edge artworks and devices. Kushiyama uses hybrid

practices and fuse elements of science, engineering and fine art practice. In the early 2000's her works began to oscillate predominantly between the sense of touch and different qualities of haptic experience. From the year 2003 she started developing and using tactile displays, focusing directly on a tactile interaction. The work exemplifying this research is called *Thermoesthesia* (2006).

In order to provide a whole spectrum of sensory stimuli when touching the artwork, and to give the recipient a real sense of temperature occurring in the natural world, Kushiyaama uses original thermal sense-displays. This enables her to create installations which not only give the possibility to interact by touching the surface of an interface, but also to sense other haptic qualities of the given piece, such as its temperature. By adding actual thermal properties to the images representing warm or cool substances the artist tries to recreate all the sensory features as faithfully as they occur in everyday life.

Fig. 2, 3 Kumiko Kushiyaama, *Thermoesthesia*, 2006, Courtesy of the artist



Thermoesthesia gives the recipients the opportunity to touch the work and experience the physical tactile engagement and also to interact directly with the images being part of the artwork. The displayed imagery ranges from leafy visualisations with warm toned floral patterns to cold ice crystals and snowflakes in wintry whites. The interaction with these simulated physical phenomena allows recipients to experience the nature occurrences in a different manner, in an artificially created environment, which resembles the natural one. As such, if the image represents cool temperature, the touch sensation feels cool as well. The intention of Kushiyaama is to provide the opportunity for rediscovery of the world as we know it in the immediate embodied engagement with the work (Kushiyaama 2006). The artwork encourages the playful exploration of perception processes through haptic interaction between computer generated images and participants. The work represents an attempt to engage the recipient in sensory immersion. What influences perception of this artwork is the fusion of the aural and tactile in the form of gentle sounds, mechanical touch and the temperature recognition. The artist ascribes her inspiration to engineering, new technologies as well

as development of robots, humanoids and virtual reality in Japan. She uses all of these elements as basis for her own ideas as well as means of implementing her creative concepts. Paradoxically, these artworks enabled by sophisticated engineering and technological developments, based on a physical contact with machines, stimulate immediate bodily contact and awareness of its sensory modalities. When thinking about prevailing and broadly Western approaches to art and art history, Kushiya notices the importance of historical context, social and theoretical background which always appears to be an essential part of the artistic debate. In Japan on the other hand, interactive art and media art in general seeks light and entertaining engagement with engineering and technological developments. It relates to the social background and the way art is valued and what is regarded as art around the world.

Masaki Fujihata

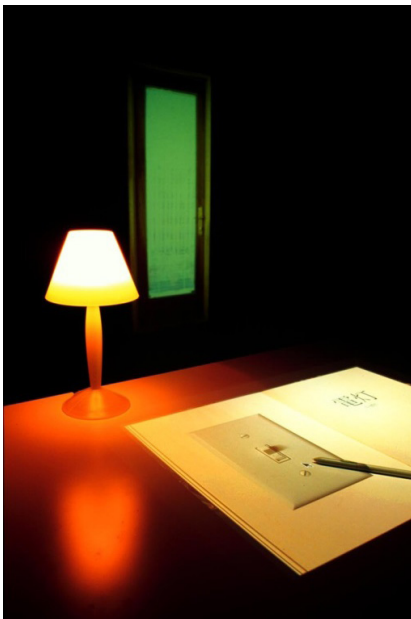


Fig. 4 Masaki Fujihata, *Beyond Pages*, 1995, Courtesy of the artist

is considered one of the first artists who contributed to instigation and establishment of interactive digital art within the framework of contemporary art in Japan. His installation *Beyond Pages* (1995-1997) remains the most recognisable and iconic of his oeuvre and digital interactive artworks in general, as it serves as a classic example of interactivity in art.¹ *Beyond Pages* is a digital interactive installation created to fit into a small darkened room, in which the real interweaves with the virtual. A desk, a chair and a lamp are the actual objects in the space and a book (the actual haptic tablet) lying on the desk, is an interface between a human and a computer.

The illustrated, virtual book, just as any other, contains words and visual images. Pictures of leaves, an apple, a stone, a door, a lamp switch, an hourglass and a simple text, can be browsed through and animated with the use of a special pen - a wireless electronic device. All of this is presented as an assembly of digital images in conjunction with acoustic signals. In this work, Fujihata deals with the fusion between the real and the virtual, combining actual objects in the room with an interface and a digital projection. As a result, he creates a coherent yet hybridised environment where physical objects are blended into an imaginary world of the artist. *Beyond Pages* requires human touch as well as involvement of the other senses. The interactive and multimodal qualities of the work enable an embodied approach to the work. Wielding an instrument which employs tactile and empowering sensation allows the participant to engage with the piece bodily and initiates auditory and visual sense perception. The experience is further dependent on implemented technology and digital

¹ Interactive art is understood as art involving participant's bodily engagement and the giving the user sense of control and a power of creation.

representation of the sensations and human experience. Participants are making sense of the works and experimenting with the medium using information processing systems in the form of an interactive book.

Conclusion

As presented in the above examples, interactive media can enable humans to externalise the whole central nervous system and engage physically with an artwork. The human physical body is treated as a whole and as such takes part in the aesthetic experience. Through interaction and embodied perception participants are able to observe and examine the space around them and perceive it in the most natural way with the aid of human multi-sensory properties, as well as by interaction between man and the machine. Moreover, every time that a human being takes part in the exploration of shared phenomena through these works created and operated by sophisticated integrated technologies, they do so from a subjective perspective of the participant. As such, the work is unique and in some sense is created anew. Each medium has some assigned qualities to it and each of the media approached differently has a particular effect on the human perception. Objects created by Fujihata exist as communication tools and are determined by the individual human sensorium and approach to interactivity. Like all the works analysed here, Fujihata's artworks do not convey aesthetic meaning unless they are being activated, explored and perceived sensorially by participants. The role of the spectator is to participate physically in the art piece and explore its interactive potential - something essentially dependent on implemented technology and digitally recreating human sensations. Participants are making sense of the works, and experiment with the medium. They use information processing systems in the form of interactive installations and objects. In conclusion, an effective critical understanding of particular artistic approaches to multisensory perception should be taken into account when investigating sensory relations in perception of multimodal art. The implications of new technologies or notions of engagement should encourage exploration of culturally rooted creative practices and acknowledge sensory features of human body in reception of artefacts. This paper only points out more effective ways of thinking about global change in communication, perception and awareness of expanded sensuality and it should be considered as a starting point to further investigation.

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Intermedia, an Updated Vision in the Early Twenty-First Century

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Keywords: Art, Design, Presentative Art, Autopoiesis,
Indisciplinarity.

What is it that characterizes the practice of intermedia thought? Is intermedia thought an actual phenomenon, or is it already out-of-fashion? Before the apparent lack of peer's consensus as to the actuality, terminology, and meaning of the term 'intermedia', this article presents the main characteristics and antecedents of intermedia thought and practice previously identified by other authors and, based on an actualized study, expands the set of these attributes, proposing the inclusion of the characters presentative and interdisciplinary. An amplified review of the literature allows us to support a philosophical approach that demonstrates the actuality and appropriateness of Coleridge's original conception of the 'intermedium', as well as the affinity between intermedia and experimental chemistry, given its transformative, laboratorial, and experimental character, and its capacity to create new media through the fusion of existing media, in an open autopoietical process.

1 Introduction

The aim of this study is to substantiate and assert the influence and emergence of an intermedia practice and thought at the beginning of the XXI century. The present dispute about the extemporaneousness¹ or actuality of intermedia practice and thought, and about the meaning² of the term itself, as a common denominator of the results of several happenings, practices and thoughts in the art and design field, were taken to be a problematic worthy of this paper. This paper summarizes theorization about antecedents and concepts that support an approach to a definition of intermedia.

By relating Higgins, Coleridge and Chemistry, we approach the original conception of the term 'intermedium' as it was proposed by Coleridge, and also its adaptation by Higgins. We affirm an affinity relationship between intermedia and experimental chemistry, emphasizing its transformative, laboratorial character, and its synthetic ability as a generator of new media. We identify serendipity, indetermination, and autopoiesis as inherent characteristics of intermedia and some scientific practices.

We clarify the distinction between intermedia and multimedia concepts, arguing from the relational and plural characters that respectively associate with each of them. We discuss changes in artistic movements that were inherited by intermedia, using several examples: in Futurism, the indecency concerning the use of any mean or of the public reactions; in Dadaism, its heterogeneous strategies and its spontaneity; in the Ready-Made, the media liberation from their original functions; in Happenings and some John Cage's work, the inclusion of the audience and indetermination. We identify the concepts of threshold, hybridism, holism, continuity or fusion, as intermedia attributes that justify for its non-categorization.

It is the aim of this text to demonstrate intermedia conception as a process of interdisciplinary creation, a process that generates new hybrid media through the systematization and development of fusion models from different expression media.

2 About Intermedia

2.1 Higgins, Coleridge and Chemistry

According to Kostelanetz (1999), Higgins made quite clear the view that there can be no limits to creative activities. Higgins (1966b) used the term intermedia to categorize art works that seemed to him to be found between media. Schneider (2000) considers that Higgins, by describing – with the term intermedia – art works that operate in the interfaces of established media and

¹ Authors such as Claudia Gianetti (2010) consider the intermedia as 'linked with the productions and theories of the seventies and from this point of view is a bit outdated.'

² There is a lack of consensus when several individuals answer the question 'what means intermedia'. Answers available at: <http://hyperinstrument.com/interviews/>

in the interstices between art and life, anticipated post-modern preference by hybridism instead of formal unity, as well as the challenge of art as a pure ontological category.

The term intermedia was used the first time in 1966, in 'the something else newsletter', with Higgins's attempt to distinguish Marcel Duchamp's from Picasso's work, as he tried to show that Duchamp's work was truly 'between media, between sculpture and something else'. We can speculate on the name itself of the newsletter – 'the something else'³ – but it is more interesting to stress the recurrent use of the word 'between' in Higgins's text. The prefix 'inter' is sustained, throughout Higgins's text, by the word 'between'. We will then consider the term 'between' as a keyword: to work 'between' several disciplines, between several kinds of knowledge and between several experiences.

The word 'between' helps us to understand and contextualize the works resulting from intermedia practice and thought. Those works fit somewhere in a hybrid area, between Visual Art, Sound Art, Architecture, Design, Performance and Science, amongst other fields. The prefix inter, from the Latin, is related to and is a synonymous of the word 'between'. So, a first etymologic interpretation of the term would translate intermedia as 'between-mediums'.

A century before Higgins, Coleridge had already introduced, in his work 'Biographia Litteraria', from 1817, the term 'intermedium'. In an interview given to Nicholas Zurbrugg, Higgins (Zurbrugg & Higgins, 1963, p. 24) confirms that he renewed Coleridge's term. In this paper, we pretend to explore the notion of intermedia as a 'transformative chemical agent'. Coleridge is quite clear: "(...) an intermedium of affinity, a sort (...) of mordaunt (...)". The intermedium is a kind of 'mordaunt'. In spite of the fact that we no longer find the word 'mordaunt' in modern dictionaries, Doctor Alice Eldridge informs us: 'I think it's an old fashioned technical chemistry term meaning a common base – like a common ancestor.' (Eldridge, 2013) Thus, we propose the concept of 'catalyzer' as an inferential approach to 'mordaunt's meaning. As a catalyzer, Coleridge's 'intermedium' establishes an initial affinity between intermedia and a chemical agent.

The affinity between intermedia and chemistry is corroborated by Sumich (2006) comparison between intermedia and experimental chemistry. Chemistry, as it is defined by the 'Collin's English dictionary', is '(...) the branch of physical science concerned with the composition, properties, and reactions of substances; (...)'.³

Eisenkraft (et al., 2006) states that the artists are chemists, for they 'study and understand the properties of specific materials – media – and find ways to explore those properties' in order to express themselves. According to this author, chemistry resumes

³ In an interview with Zurbrugg, Higgins remember what he wrote in his 'The Something Else Manifesto': 'Whatever the other people are doing, I'll do something else.'

to change, and artists become chemists through their need to understand the materials between the materials they use. The understanding of the properties and characteristics of materials has been a fundamental component of artistic production since antiquity. Levere (2001) entitles his 'Chemistry History' as 'Transforming Matter', and he summarizes the technical competencies of chemistry applied to the manipulation, separation, combination and modification of different substances. These competencies are much alike to those practiced by intermedia artists and designers. Gardinali (2012) explores the relation between chemistry and art and states that since the discovery of fire, artists have made a creative and exhaustive use of the media which were available to them. It is consensual that both artists and chemists activity transforms.

Moody (2000) refers a mutual relation between materials and artists, and he states that both 'artists and chemists deeply value personal interaction and experimentation with materials'; or, in other words, the laboratorial component that allows the growth of understanding about the media. Glusberg (1980) already considered intermedia as 'an unusual laboratory, though, where technical and communications media are the guinea pigs'. The affinities between chemistry and intermedia are made visible in the fact that both are essentially processual, laboratorial and transformative, which enables the unexpected, serendipity and indetermination.

Serendipity may be one of the major drives for the artists and chemists in their work processes. Spector (2003) states that it is chemistry itself that seduces the chemist's imagination, which sometimes produces an intrinsic tension between the charm of the work they are developing and its final result (p. 253). This drive (intrinsic and extrinsic) is also absolutely true to intermedia practice and thought.

The identified affinities are also sustained by the arguments of Spector and Spalding discussion (2003) about art and chemistry, in which they identify, for instance, the resource to metaphor, transformation, synthesis, the production of products, symbolic language, experimental vocabulary, tools and equipment. These resources are undeniably recurrent both in the fields of intermedia and chemistry. Kultermann (1980) had already identified one of these resources as characteristic of intermedia when he states: 'One of the characteristics of intermedia is its synthesizing character'. Roald Hoffmann is another convinced supporter of the deep connections, affinities and relations between art and chemistry. One of them is precisely the creation of media (any type of media, from material to conceptual) previously non-existent. Hoffmann (1993), that locates chemistry in the field of science, states:

Art and science share a desire for knowing that which is not yet known. They share so many things: the nature of inquiry, the intellectual process, the formulation of ideas, a concentration on the observable, a deep examination of the nature of perception and the ways perceptions change with the observer. Chemistry and art synthesize by melding old knowledge with new observations to provide us novel concepts of nature or of the human relationship to nature. (p. 9)

In this way, intermedia generates something new, in the threshold, from the transformation of existing media.

Spector (2003) states:

Much of the identity of chemistry as a discipline is related to the generation of materials that have not existed before and have no natural equivalent, rather than to understanding what exists in the natural world—what chemists like to call “novel” molecules, compounds, or materials. To me, all these issues of natural/synthetic/imitation/novel also relate to issues of originality, which is another point of connection between chemistry and art (...). (p. 240)

If, in the previous quote, we substitute the word chemistry by intermedia and the word materials by media, the sentence will still make perfect sense and will reinforce one of the main ideas of this paper: intermedia as an essentially presentative phenomenon, and not representative or mimetic, as so many of the more traditional artistic forms.

If intermedia generates new media from the transformation of existing media, then we can both affirm the actuality and antiquity of intermedia, because the thought and practice of generating media from the transformation of existing media is a constant throughout human history. Nevertheless, intermedia has not always been recognized and validated in the artistic and academic fields, which were conceived as a hierarchic system of knowledge, of disciplinary division that evolved from the millennial fission between rationalism and idealism.

Another affinity between intermedia and chemistry is related with the question of ‘indiscipline’ and the breaking of disciplinary limits, as a quality of the intermedia. Chemistry can also be indisciplined, for according to Spalding (2003) ‘It is surprising that chemistry can take us outside the bounds of more traditional notions of scientific reason.’ (p. 236) Hoffmann (1993) states that ‘the aesthetic principles of science are not that different from those of art. Beauty, elegance, deep understanding are sought by chemists just as much as they are by artists’ (pp. 8-9). We may conclude that intermedia is precisely a transformative, laboratorial, experimental, synthesis process, able to generate new media.

2.2 Serendipity, indetermination and autopoiesis

When he was co-organizing the book/exhibition 'Chemistry Imagined', Hoffmann experienced indetermination and serendipity, as he explains by stating that his 'initial conception [...] was typically scientific, therefore linear. (...) But the nature of the creative process has ways of subverting such linear plans. And the work of art (...) carves out its own space.' (1993, pp. 9-10) Hoffmann confirms the idea that often the artist's production is induced and oriented by the process of production of the work, process in which all the (in)determinants should be included. Indetermination deserves, as an intermedia quality, a deep discussion, and it is well to remind here that, for some scientists and philosophers, indetermination is also a quality of science. Elstob (1986) refers to how Karl Popper demonstrates that 'even within its own conceptual framework the deterministic scientific view exhibits an inherent indeterminism.' (p. 80) Ilya Prigogine – a physicist and a chemist – challenged scientific determinism as he affirms indeterminism and chance as integral parts of systems theory. According to Elstob (1986):

'(In Prigogine's treaty), the indeterminism arises from thermodynamic bifurcation points where random events are what determine the future course of a system. A consequence of this view is that structures that now exist in the whorl may have resulted from purely chance events, thus denying the universal operation of determinism.' (p. 80)

Zatti (2003) discusses the possibility that the nature of the universe might be accidental. Indetermination as something inherent to life and nature justifies its use by artists that try to approach and integrate their work in life and nature. In what concerns intermedia, indetermination is associated to its creative processes, taken as open autopoietic, transdisciplinary and interdisciplinary systems.

We use here the expression 'open autopoietic' systems as a meta-abstraction from the concept of 'autopoiesis', introduced by Maturana and Varela (1980). To be more precise, we use it as an abstraction of Luhmann's concept of 'autopoiesis', which is already an abstraction from the Maturana and Varela's original concept. To these authors, 'the establishment of any system depends on the presence of the components that constitute it, and on the kinds of interactions in which they may enter.' (1980, p. 95) Kultermann (1980) also characterized intermedia as an open system, giving as an exemple the relationship between audience and work. According to Seidl (2004), in the original concept of

autopoiesis, 'the elements of autopoietic systems are not produced by something exterior to the system', i.e., 'all the processes of autopoietic systems are produced by the system itself'. Seidl states that 'autopoietic systems are operatively closed', because there are no operations coming from the outside entering the system, nor vice-versa.

Luhmann indirectly applied the concept to sociology, as a radical abstraction from the original biological concept, transforming it into a general, transdisciplinary and open concept of autopoiesis. Luhmann states that 'the emerging insight is that the phenomena of interest for evolution are special kinds of systems: open systems, that is, those that can exchange energy, matter and information with their environment.' (1986, p. 148) A decade later, Guattari (1995), with or without knowledge of Luhmann's abstraction, also reformulates and expands Maturana's original concept, as when he writes:

Autopoiesis deserves to be rethought in terms of evolutionary, collective entities, which maintain diverse types of relations of alterity, rather than being implacably closed in on themselves. In such a case institutions and technical machines appear to be allopoietic, but when one considers them in the context of machinic assemblages they constitute with human beings, they become ipso facto autopoietic. (1995, pp. 39-40)

According to Doruff (2008), Guattari appeals creativity as a means to expand homeostatic, self-referential and closed systems, turning them into open, new, imaginative systems. Hall (2010) considers that 'applied to aesthetics, autopoiesis replaces an external objective view of art with an internal relativistic understanding of creation. And this can be described as a self-functioning system of aesthetics that is open to negotiation.' Spielmann (2005) states that intermedia works are formed through the exchange and transformation of elements originating from different media. In this perspective and on these grounds we may abstract the expression 'open autopoiesis', open to exchanges with the exterior that contribute to the modelization of the structure of intermedia systems of creation and production, as well as of their resulting works. Maturana's closed concept evolved to an open concept of autopoiesis, so that we may say that the dynamics of intermedia processes are open autopoietic dynamics.

The spectator may be one of the components of the intermedia system, i.e., a medium. Having no intention to deny the Author's accountability, we affirm that the hybrid Author/Artist/Designer/Producer has no nuclear role, but is merely a necessary component of the intermedia system, is merely also a medium. Thus, the intermedia follow from the interaction of the media that compose

it. If we consider interaction and exchanges between media as a communication phenomenon, then intermedia is indisputably interactive and even enactive.

Clark (2011), who studied autopoiesis as a basis to the expansion of interactive artistic system, recovers the classical model of the artistic system proposed by Cornock and Edmonds (1973), composed by the artist, the participants, the work, the environment in which these elements are placed, and the dynamic processes or interactions that follow from this constitution. On the contrary, this paper suggests that intermedia emancipates from the system, posing itself as its own system – open autopoietic – of conception, production and materialization, and not as an element or component of the system.

In regard to the application of autopoiesis to esthetics, Hall (2010) considers the interactive art work as an evolutionary system, where the art object and the spectator become co-organizers, creating an emergent esthetics, one that we might call endoesthetics. Hall's idea is very close to the concept of enaction when we take into account the capacity of sharing proposed by Teixeira (1998), when he considers that the 'activity of communication doesn't consist in the transference of information from the emitter to the receptor, but in the mutual modulation of a common world through joint action.' (p. 147) The joint action of human beings as intermedia media confers its evolutionary character of an enactive interface. Intermedia is then a kind of hybrid of living beings and non-living beings, such as mechanic, electronic or informatics systems. This hybrid character is sustained by Barton (2008) when he states that 'intermedia often attempts to enact the symbiosis of body and machine, locating each within the lived context of contemporary experience.'

Let us remind the 'autopoietic principle' of the 'hybrid constitution' proposed by Francesco Monico (n/d.):

Every living and non-living being has to be respected in its "self-creation" and in its expression of a fundamental dialectic between structure, mechanism and function. As an organized unity, as a network of processes of transformation and destruction of components which through their transformations continuously regenerate and realize the network of relations that produced them, and constitute it as a concrete unity in space in which they exist by specifying the topological domain of its realization as such a network.

This principle indicates the ambiguous character of the intermedia as a consequent unity of its own autopoiesis: the unity of the unique, of the uniform, of the conform and of the homogeneous, but also the unity of the deformed, of the diverse, of the

distinct and of the heterogeneous. Coleridge, in 1817, defined the 'intermedium' as a catalyzer, Cornock and Edmonds, in 1973, considered the artist as a catalyzer of creative activity, and in 2013 'Ars Electrónica' promotes an exhibition commissioned by Manuela Naveau, whose theme was the artist and the work as catalyzers. The untimeliness of the association between the terms art work and/or artist and catalyzers gives intermedia constant actuality.

2.3 Multimedia and Intermedia

Intermedia term, coined by Higgins, is previous to Multimedia term (Zuras, 2010). In order to clarify the distinction between intermedia and multimedia, let us hear what Frank (1982) wrote about this subject:

Intermedia, in effect, denotes the wholly hybrid art forms that result from a seamless fusing of approaches and attitudes originating in the traditional arts. The elements in Wagner's operas – music, libretto, stage design and costumes, dance (such as there is) – can be functionally isolated from one another without complete loss of coherence or even integrity. (1982, p.58).

Gesamtkunstwerk is considered to be a multimedia work. As a combination of visual and sound arts, Frank places it in the category of those works which merely overlay media. Frank refers that 'the cross-referencing and combining aural and visual art is part of a wide realm of cross-artistic and even pan-artistic activity which has pertained for centuries. Multimedia manifestations comprise part of this activity.' (Frank, 1982, p. 58) Ox (1999a) emphasizes the complete difference between the concepts of intermedia and multimedia. To this author, whereas in multimedia the content is simultaneously presented in more than a medium, the intermedia combines structural and syntactic elements of different media in a single new medium. Higgins (1998) established a differentiation between intermedia and multimedia, recognizing that the former was a kind of conceptual fusion. Spielmann clarifies the distinction between intermedia and other approaches, such as multimedia, hypermedia or mixed media. The author argues that the latter may be compared between themselves because they describe the 'expansion of a singular media in terms of accumulation', whereas in the intermedia, instead of accumulation, the expansion results from a process of 'transformation'. In spite of being considered merely multimedia, Wagnerian Gesamtkunstwerk, according to Wurth (2006), premeditated, but didn't achieve, the total connection of all the media in an amalgam with no origin. And, according

to Wurth, Wagner's approach failed because it affirmed the separation and the hierarchy between the media.

Wurth (2006) writes: For Wagner's programme of "together-art" feeds, precisely, on medial limits: in his outlook of the artwork of the future he starts from a hierarchy of the temporal ("human") over the spatial ("plastic") media and, moreover, situates each of these media within their conventionally assigned domain. Thus, painting and music or poetry are not so much fused as put together in the sense of combining while retaining their respective roles. (p. 7)

This point of view sustains that Wagnerian opera, oriented to the proscenium, is not a transformative amalgam, a confusion between arts and senses or a contamination between the media, but only a mere combination of separate parts. Meier (2012, p. 134) denominates Gesamtkunstwerk as 'non total', for the media merely collide one with each other, in a multimedia dynamics, instead of interacting one with each other, as it happens in intermedia dynamics. Meier further distinguishes Gesamtkunstwerk from intermedia, insofar as, in the first, different media cooperate in a complementary way aiming totality, while in intermedia, what happens is precisely the deconstruction of the total art work. Meier remarks: 'It is in this sense that the Gesamtkunstwerk aims at the full representation of human experience—the total work of art that should express all of life's experiences, but does not create a new life experience.' This last argument from Meier allows us to sustain that intermediality pretends to afford new life experiences, to expand the scope of experiences lived by the public, and not to make any kind of representation.

Although there is a clear distinction between multimedia and intermedia, the two can be related. Glusberg (1980) considers that the multiplicity of media, multimedia, is the infrastructure of intermedia, conceived as the totalization of the artistic forms. This author sees the intermedia as a revolution of total scale in art and affirms that the intermedia, 'in addition to being multimedia, is also transmedia'. Dias (2012), who also considers the opposition between the terms 'multi' and 'inter' in several contexts, considers the 'multi' as the confirmation of diversity and plurality. The 'inter', to Dias, is relational. Dias suggests that the multimedia 'come' before the intermedia and affirms that the relational character of the intermedia plays a constitutive role: '(...) the time of relation between the media is the time of production of the media themselves'. In other words, Dias sustains the idea that intermedia production is the production (synthesis) of new media.

In a cultural context full of frontiers, Fornäs (2002) affirms the advantage of the relational of the ‘inter’ over the pluralism and the combinatory of the ‘multi’:

The general pluralism of the multi- has its very important points, but the relational inter- opens up wider doors toward new kinds of processual cultural studies, by allowing for a great range of different kinds of connection, beside the mere addition of elements. This stress of the inter- is a way to navigate away from the traps of structuralism and systems theory, where dynamic relations tend to become petrified into relatively closed totalities. (Fornäs, 2002, p. 16)

Fornäs describes intermediality not only as relational, but mainly and precisely as the mixture of the breaking of the rules and the transgression of frontiers and boundaries. To this author, the liberation of disciplinary restrictions is one of the necessary conditions to creative culture. To Fornäs, multimedia are only combinations of separable media, while the intermedia concern ‘the passages between the media that demand thresholds’. We may conclude that intermedia is also a ‘crossing-field’, a hybrid field of construction that operates in relating that which was separated and disperse. In Fornäs’s thought, it is important to consider that the operations and mixtures ‘of’ and ‘between’ the media demand for human agency and contextualization. The media relate through human contextualized interaction.

Intermediality (...) is when media (...) are connected by specific people (interpretive communities) in specific settings (physical, virtual and social spaces). (...) People necessarily mediate between media and media between people. (Fornäs, 2002, pp. 19-20)

2.4 Futurism and Dadaism

Shatnoff (1967) considered that some of the first Dadaists shows in the twenties were in fact intermedia. Gilbert Chase (1967) indicates the work of Cage in the beginning of the fifties as seminal to the development of what would later be designated as intermedia, in at least two aspects: the suppression of musical notation, as an opportunity to open the space-time of the work to the acting of the performer, and the random happenings generated in/by the environment. Kirby (1965) affirms that each one of the dimensions of Cage’s work was already prefigured in the works of Futurists and Dadaists. In 1913, the Futurist Luigi Russolo writes a letter/manifest – ‘L’arte dei rumori’ – that Christensen (2009) considers one of the most influential texts in the musical aesthetics of the twentieth century. In it, Russolo (1967), who radically

desired to change the perception of what might be considered music, expresses his claim that the noisy sounds of machines and urban life should be considered as musical tones and timbres. As the 'arte dei rumori', the 'esthetics of noise', also designated as 'bruitism' and explored by the Dadaists, also aimed, according to Niebisch (2013), 'to end this chauvinism against noise'.

In this sense, Futurists advocated a shameless attitude in relation to the use of any media in the artistic event. According to Tisdall (1978b), Futurists turned their back to the 'closed' life of the 'intellectually cultivated', a gesture that might be seen as an anticipation of the transgression and challenging attitude of the intermedia before institutional schemes and conventional definitions. Another aspect of Futurism that anticipates what would come to be the practice of Dadaists and integrates our concept of intermedia is the use of the public spontaneous reaction. Marinetti, according to Tisdall (1978a), by expanding the new form of performance, includes a greater degree of audience participation. The rather extreme use of the audience by Dadaists is even considered by Niebisch to be parasitic.

Foster (2003) considers that another aim of Dadaism was pandemonium, a total mess, the creation of a tumultuous and no-rules place. Kristiansen (1968) corroborates this idea of pandemonium, by arguing with the fact that Dadaism had a clear and unmistakable influence on 'happenings', and he quotes Clau Backman use of the same term: 'orgiastic pandemonium'. Kristiansen considered Dadaism as the opposite of an artistic movement, as a denial of all the schools, born of a necessity for independence and of a distrust before unity. The more important Dada strategies were the 'invention' of the 'readymade', the use of collage, of the assembly and the implantation of chance. These strategies, in addition to being mechanisms for the materialization of artistic objects, are also a resignation of the more traditional forms of artistic work. To buy, to edit, to fix, these were the new working forms, at that time far from being as familiar and applied as they are today. Walter Benjamin, in his polemical essay 'The Author as a Producer', congratulates Dadaists, pointing out the revolutionary force of Dadaism in the fact that it defied art's authenticity (Benjamin, 1934/2008). The artists that used chance were yet more challenging to the traditional modes of artistic work; either it was a found object or an automatic drawing, chance allowed artists to abandon the final control over their art works, simultaneously diminishing the quantity and the effect of their labor. Dadaism, according to Kristiansen (1968), anticipated and influenced the 'happening' through the heterogeneous mixture of distinct forms of expression, specially by way of three of its theories: 'bruitism', simultaneity and spontaneity. The two last theories are

essential in the construction of the intermedia concept, for intermedia works generally exhibit simultaneity of media in shaping the work, and also spontaneity of the human being, since he is free to act without no previous orientation or staging.

We can't deny the influence that the 'fluxus' movement had in what Higgins designated as intermedia. Yet, in this paper we strategically neglected that influence – given its temporal proximity to Higgins – and chose to discuss the antecedents that pre-figured some of the strategies identified as characteristics of the intermedia.

2.5 Readymade and Happening

The idea of pure media, pure formats, is inappropriate to understand intermedia dynamics. Higgins coined the term Intermedia as a way of criticizing the separation, distinction and categorization of the media used in Art. These 'almost mechanical' hierarchies and separations, emphasized during Renaissance, lasted at least until XX century and was associated to society's division and subdivision in classes. According to Higgins (1966b), the tight division between social classes was absolutely irrelevant, and he also considered unnecessary the observations of art that aimed only to shelve it inside one or another particular category.

To Higgins, the Ready-made and the Happening break the idea of pure media or formats:

The ready-made or found object, in a sense an intermedium since it was not intended to conform to the pure medium, usually suggests this, and therefore suggests a location in the field between the general area of art media and those of life media. (Higgins, 1966b)

We can see this new intermedia space in Duchamp's urinal: 'He took an ordinary article of life, placed it so that its useful significance disappeared under the new title and point of view – created a new thought for that object.' (Harrison & Wood, Eds., 2003) The subversion or transformation of the functionality of a media, evident in the ready-made, is also one of the main principles of intermedia – to liberate the media from their original functions, opening the possibility to create new thoughts, new ideas and new functions to already existing media. We may conclude that the functional transformation of objects, materials and languages integrates the process of creation and materialization of intermedia works.

We might speculate that this ability to transform the functionality of the objects is one of the characteristics that distinguish human beings from the other animals. Schneider (2000)

introduces in the artistic, political and social lexicon the term 'nomadmedia', concerning the nomadization of media. In spite of having been created in the context of political, social and artistic activism, this term is useful to designate the intermedia liberation and subversion of existing media. In the actual context, we may define the nomadization of media as the process of transporting media out of their original contexts and functions to operate in other contexts. Duchamp's practice, in the 'Fountain', points to the concept of 'prosume', which shows up as inseparable from actual intermedia dynamics.

Intermedia practice and thought freely combines the production, the consumption and the re-using of media. We may for instance underscore the use of hardware and software (as programming environments and languages), for both uses are simultaneously production and consumption acts. We can consider as readymade either an 'arduino' or a programming language, ready to be consumed as they in fact are; but, simultaneously, they also imply the production of an electronic circuit and a program.

Higgins refers the inclusion and participation of the spectator in the 'happening' and underscores Kaprow's work as a pioneer to this kind of artistic event, emphasizing his philosophical approach to mediation in the relation between spectator and art work. Higgins (1966b) criticizes 'proscenic theatre', with its mechanical division of actors, production staff, audience, argument and script, for its lack of portability and flexibility.

Thus the Happening developed as an intermedium, an uncharted land that lies between collage, music, and the theater. It is not governed by rules; each work determines its own medium and form according to its needs. The concept itself is better understood by what it is not, rather than what it is. (Higgins, 1966b)

As it is impossible to give an objective definition of what intermedia is, we should keep in mind that Higgins confronts two possibilities: Intermedia as a huge and inclusive artistic movement, or, by contrast, Intermedia as an inevitable and irreversible historical innovation in reaction to the compartmentalization of history itself.

Higgins introduced the term Intermedia in February 1966, and in the next month Alan Kaprow (1966) uses it in association with fusion and hybridization taken as parallel forms of a thought that is closer to life. This was the second written register of the term Intermedia. We should not minimize the considerable immediate impact that the 'readymade', the 'happening' or intermedia had in the artistic context. In the same year, Corrigan (1966) immediately refers to intermedia experience and the happening as

signs of new forms of expression with unpredictable evolution. The inclusion of the audience, as much in Futurists and Dadaists works as in the happening and the intermedia, as a resource involved in the work's materialization, brings indetermination to the work itself. Almost 50 years later, the questions and drives of the readymade and the happening explored by the intermedia are still open and actual.

2.6 Intermedia Space-time

We can hardly categorize intermedia works as uniquely sculptural, plastic, musical, or architectonic, because they don't exclusively frame in any of these categories, while at the same time they in some way frame into each one of them. They are the product of interactions between independent space-time systems (Ox, 2001), they occupy a hybrid and ambiguous space-time. Cseres (2009) places intermedia work in that space-time between media, codes, types, genders, forms, tools and institutions. Cseres states that intermedia works defy conventional classifications, institutional schemes, as well as conventional definitions of art and creativity.

Intermedia space-time, between categories, between media, between concepts, is not the void; on the contrary, it is a space-time filled by possibilities, countless combinations and configurations. Fornäs (2002) alludes to this intermedia space-time as a transgression space-time, due to the fact that the intermedia operation occurs precisely at the threshold zone of the media, the disciplines and the concepts. In order to ground his idea of the threshold as a zone of space-time and not a boundary, a border or a division, Fornäs uses Walter Benjamin's conceptualization of the threshold:

The threshold must be carefully distinguished from the boundary. A Schwelle – threshold – is a zone. Transformation, passage, wave action are in the word *schwellen*, swell, and etymology ought not to overlook these senses. (Benjamin, 1999, p. 494)

A threshold is a transition zone, while a border is a line that separates. Borders inhibit movements, while thresholds invite innovative change. As a matter of fact, these thresholds seem to be part of human nature, for, according to Fornäs, human communication and interaction are recognized as sources of threshold experiences.

Baker (2003b) designates the intermedia space-time as 'betweenness', and it seems that he attributes elastic and flexible properties to this betweenness, as when he states that it stretches/expands media definitions, an expansion that occurs either

‘in-between’ or ‘inside’ the media themselves. Meier (2012) states that this space-time, which he designates as ‘space in-between’, ‘(...) has the potential to create genuine thought as an event within the concentrated form of intermedial artwork.’ In other words, intermedia space-time is simultaneously a thought space-time and a thought generator space-time. Ascott (2013) designates this space-time as interstitial, and he proposes the concept of ‘interstitial creativity’ in reference to any type of practice that operates between the borders of media, gender or types of knowledge, with no recognition of any kind of hierarchy between them. We may conclude that these intermedia dynamics operate precisely in this interstitial space-time, full of matter and structure.

Intermedia thought and practice also have a common denominator in the holistic attribute. Although there are not many bibliographical references that use the term in association to intermedia, we may indicate Friedman’s contribute (2007), where he uses the term as an adjective to qualify the intermedia as a holistic or unified program, in order to distinguish it from other concepts such as multimedia.

The hybrid character of intermedia is another consensual and transversal concept. Higgins (1967) states that intermedia covers the art forms that are ‘conceptual hybrids’, in-between two or more traditional media. Frank (1982) states that the more radical aspects of artistic crossings should be considered under intermedia scope, considering intermedia as the totality of the hybrid art forms. McCombe (2006) presents intermedia exactly as a synonymous of hybrid:

These three works can be regarded as hybrid or intermedia works in which traditional art form boundaries are blurred through the intertwining of music, text, video and performance. (...) I believe that a hybrid or intermedia arts practice provides a much more fruitful and exciting creative vehicle, both in terms of the individual composer/artist/creator and in terms of the development of new work that articulates a variety of relationships between art forms and media. (McCombe, 2006, pp. 299 & 309)

McLuhan (1994) refers to the hybrid meeting between two media as an occurrence with great artistic, social and physical transformation potential, arguing that the ‘meeting of two media’ can, amongst other possibilities, create new forms. ‘The hybrid or the meeting of two media is a moment of truth and revelation from which new form is born.’ (p. 55) Kase (2009) shows that McLuhan used hybrid projects which functioned as experiences able to challenge the social conventional patterns of perception and thought. Friedman (2007), also highlighting the hybrid character of intermedia, paraphrases Higgins’s concept: ‘the term

intermedia referred to art forms that draw on the roots of several media, growing into new hybrids.’ (p. 14)

It seems consensual that the intermedia generate something liminal and new. Ox (2001) confirms this approach: ‘Intermedia is a combinatory structure of syntactical elements that come from more than one medium but are combined into one and are thereby transformed into a new entity.’ (p. 47) Dorfles (1980) refers to osmosis, symbiosis and the confluence of the varied artistic languages as a trend that fosters contamination between languages and counteracts the ‘stagnation’ of pure languages. Dorfles relates intermedia with the new technological and mechanical discoveries, considering it as creator of a new language and of linguistic specificities constituted by the adoption of several codes. We would like to highlight the idea, in Dorfles thought, of the intermedia as a renaissance of the global creativity of the human being. Ascott (2013) affirms and actualizes this concept by designating it interstitial creativity:

Artists will look anywhere, into any discipline, spiritual or scientific, immediate or distant in space or time, any technology, ancient or modern, to enable the untrammelled navigation of mind, and the open-ended exploration of consciousness.

We recognize no meta-language or meta-system that places one discipline or world-view automatically above all others. We look in all directions for inspiration and understanding: to the East as well as the West; the left hand path as well as the right; working with both reason and intuition, sense and nonsense, subtlety and sensibility.

Synthesizing all the perspectives discussed above, we may say that intermedia operates, not only in the interstitial space, not only between boundaries and borders, but also, and mainly, at the threshold of media.

3 Conclusion

The mixture and fusion of media, out of which new media emerge, is perhaps a constant in the history of mankind. Nevertheless, a proper designation to this kind of activity was only established in the field of arts around the sixties of last century. Even the subversion and transformation of media functionality, validated in the artistic field with the introduction of Duchamp’s Ready-made and the changes brought out by Futurist and Dada movements, is also a constant in the evolution of mankind, for human beings have always felt the will and want to create new media and transform them. From this untimely point of view, the age of the media

has no longer any sense, because all of them were young and will become old, all of them were high-tech and will become low-tech. Intermedia is then as old and modern as the human being, in spite of the fact that artistic and academic fields not always have sufficiently integrated and validated it.

Intermedia dynamics, besides operating at the thresholds and in the interstitial space-time of media and disciplines, can also integrate interdisciplinary, transdisciplinary and multidisciplinary actions. However, the aim of this paper has been the characterization of intermedia dynamics as mainly interdisciplinary, considering that the prefix 'in' can be simultaneously interpreted as a negative value or as a place and movement inside discipline. Thus, we may characterize intermedia dynamics of practice and thought as interdisciplinary, for, following the requisites of its own actions, they indiscriminately act 'in', inside the disciplines, using their most deep principles and premises, but also 'in', indelicately negating those same principles and premises. In this way, we simultaneously challenge and actualize Higgins proposal, for whom intermedia operated essentially between media, between disciplines.

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Visualising Electromagnetic Fields: An Approach to Visual Data Representation and the Discussion of Invisible Phenomena

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Keywords: Data Visualisation, Invisible Technologies, Interactive Art, Data Expression, Communication, Photography, Light Painting, Education, Critical Discussion

This paper presents the process, approach and results for *Visualising Electromagnetic Fields*. A project that produced a toolkit and visual vocabulary for technological exploration – through light-painting and long-exposure photography – to capture, visualize and communicate invisible electromagnetic fields that surround everyday objects. The project acts as a case-study to answer a need for work that combines scientific and artistic practices. To create a open dialogue between the public, scientists, designers, and engineers in a way that provides a visual language for understanding and critical discussion.

1 Introduction

In 2013 when the project was first created and published there were (and still are) many different tools, techniques, platforms, sensors and processes for the capture, recording, visualisation and quantification of data. Especially ‘invisible’ data, which is defined in this paper as statistical information that can be measured scientifically, but where the data describes an invisible phenomena that cannot be seen by the human eye.

Long before interaction design existed as a discipline, Manzini argued that materials, including digital and interface technologies, are under such rapid change that there is a widening gap between them and their cultural understandings. (Manzini & Cau 1989)

The project developed from a need to address a growing concern. As designers, scientists and engineers we often use and talk about invisible technologies, but how can we be sure our own mental model of these technologies is 1) accurate and 2) is a mental model shared by others, primarily our target-audience? The project was presented as an example of discursive design whereby the aim was to provide a visual vocabulary that could allow for *dialogue* (Bohm 1990) around an area of technology with limited public understanding but wide public usage – electromagnetic fields.

2 Invisible phenomena

Electromagnetic fields (EMF) are an ideal example of a phenomena that are used and produced by most everyday technologies, but most documentation and information remains in the scientific and engineering domain. Information and explanation is not usually designed for use by the general public. In recent years the design industry – who work primarily in the consumer market, producing products, services and systems for public – have actively promoted the use of *seamlessness* (Ratto 2007) in design proposals and creative solutions. Deliberately ‘making invisible’ many of the technologies that make a system or product function in a desired way.

An electromagnetic field, as the name suggests, is made of 2 components, the electric field and the magnetic field. The magnetic field can be understood using Ampère’s Law, which is an electromagnetism law that relates the magnetic field in a closed loop or surface with the electric current circulating through that same loop:

Fig. 1 Ampère’s Law (Duarte 2014)

$$\int \vec{B} \cdot d\vec{l} = \mu_0 \cdot i$$

The electric field can be understood using Gauss's Law, that describes the relation between the electric field flowing through a closed surface, the Gaussian surface, and the sum of the electric charges inside a volume, limited by that same surface:

Fig. 2 Gauss's Law (Duarte 2014)

$$\int \vec{E} \cdot d\vec{A} = \frac{Q_{int}}{\epsilon_0}$$

The project combined both, using the built-in magnetometer-sensor inside the iPhone 4 and LG Nexus 4 smartphones. These sensors are capable of measuring both the magnetization of a magnetic material like a ferromagnet, and the strength and direction of a magnetic field at a point in space.

2.1 Previous approaches to electromagnetic visualisation

Electromagnetic fields have been the focus of scientific and artistic study and material-exploration for several decades. From the 1820's scientists such as André-Marie Ampère and Hans Christian Ørsted¹ were demonstrating their scientific and mathematical discoveries through the design of scientific instruments that could visualise the unseen magnetic forces around objects with an electrical charge.

In recent years within the field of Design, the fascination with invisible phenomena has developed beyond data visualisation, to allow provocation and a critique of previous modes of explanation and aesthetic methods of representation. In his book *Hertzien Tales*, Anthony Dunne dedicates a chapter to the “radio space”, although this is not an attempt to visualize the invisible, but to “explore new aesthetic possibilities for life in an electromagnetic environment”.

Whereas cyberspace is a metaphor that spatialises what happens in computers distributed around the world, radio space is actual and physical, even though our senses detect only a tiny part of it. (Dunne 1999)

3 Photographic approach

There is a history of using photographic techniques in the sciences and Human-Computer Interaction (HCI) research to capture and understand complex or invisible interactions with the physical world. To use photography as a visualisation tool that can be used to track and display information.

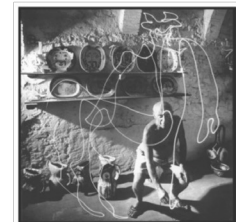
¹ Oersted's law. April 21, 1820.
Accessed at (http://en.wikipedia.org/wiki/Oersted%27s_law)

Light painting is a photographic technique that has a history of being used to track motion and changes in space, over time. One of the earliest examples of this photographic technique is *Pathological walk from in front, made visible by incandescent bulbs fixed to the joints* by Étienne-Jules Marey and Georges Demeny (see Fig 3). The motivation is often because of the power of the photograph to engage with an audience without a requirement for technological understanding, in contrast to a diagram or statistical information that requires mental processing and ‘reading’ of information.

Marey wanted to give a visible expression to the continuity of movement [...] and to do so within a single image. Only this, he believed would give him quantifiable results – photographs from which measurements could be taken. (Braun 1994)

In addition to quantifiable information that could be stored within a single photograph using the light-painting technique, artistic expression and human emotion could be expressed and shared. The photograph acting as a discussion point between the author and the audience. Artists such as Marey & Demeny, Gilbreth, Man Ray and Pablo Picasso (in collaboration with Gjon Mili) used light-painting as creative tool for expression and storytelling in their practice between 1930–1950 (see Fig 3).

Fig. 3 Light-painting works (Marey & Demeny 1889), Cyclegraph (Gilbreth 1914), and “Picasso draws a Centaur” (Picasso 1945)



3.1 Light-painting technique

The photographic technique used for the project is exactly the same process as used by artists such as Picasso et al. to produce their light-paintings of the 30s and 40s. A camera with a small aperture size is placed on a tripod and the shutter is released for a long period of time. Between 60 and 90 seconds were used for the creation of all photographs in the project, but it is most likely that Picasso and Mili would use a much longer time period, given the capabilities of the camera equipment that was available to them at that time. While the shutter is open, a strong light such as a candle, led, or mobile phone screen can be moved in front of the lens, creating a trail of light that is capture by the cameras digital sensor (or photographic film).

When the shutter is finally closed, the remaining image will be the result of all the light that travelled through the lens during the entire exposure period. Both the bright light used for light-painting and any ambient or stage lighting that was also present.

4 Everyday objects

A key motivation for the project was to capture and communicate invisible phenomena surrounding technology, to an audience without any prior technical knowledge or experience. We chose everyday devices and household items as the central objects for investigation, so that the widest number of viewers could identify and relate to the project. Everyday objects such as an Apple MacBook Pro, Radio alarm, iPhone and Google Nexus 4 were photographed. The purpose was to engage with a wider audience and provide a visual language and toolkit that can enable conversation and discussion across multiple disciplines, experiences and understandings.

It is only through a process of exploration and revelation that we are able to develop our 'object-world' understandings as designers, in order to assemble new perspectives on, and meanings around, emerging technology. (Arnall 2013)

Through experimentation we developed an understanding of both the photographic principles and limitations of light-painting, and the technical specifications of the magnetometer sensor inside an LG Nexus 4. Using the open-source programming language *Processing*² and the open-source *Ketai*³ software library to access information from the phone's sensors we created our own simplistic real-time data visualisation application that could run on any Android enabled device.

4.1 Data communication

After the creation of a very simple software tool, the next step was to experiment with different visual languages that might help us communicate and visualise the material qualities of the EMF that can be detected around everyday objects.

Shape, size, colour, speed, depth, resolution and time were all parameters that could be adjusted for each image. Through experimentation we arrived at a limited palette that could be successfully and repeatedly used to visualise and compare the EMF field of any object.

² Processing programming language.
Accessed at <https://processing.org/>

³ Ketai Library for Processing.
Accessed at <https://code.google.com/p/ketai/>

4.2 Artistic expression

Understanding and clear communication was always a primary consideration for each aesthetic decision when creating the images. But the success of the project relied on how engaged the public would be with the images and videos that were published. Therefore a careful balance was made between data representation and the generation of an attractive visual language that would intrigue viewers and provoke conversation and discussion.

This artistic expression is present within every single photograph, from the lighting and composition to the crop of the product and the resolution of the light-painting inside the photograph. Most obvious is the affect that the movement of the hand will have on the final photographic image. To avoid the further removal of information from the photographic image we constructed systems and methods of rigor, so that we could repeat the same movements and gestures to generate similar subsequent photographic images that could be used to contrast and compare electromagnetic fields. Still photography was used to identify areas of EMF that could be detected and visualised, then the gestures were repeated – sometimes more than two-hundred times – to create a photographic sequence that could produce an understandable moving image.

Fig. 8 Final visual language through photography



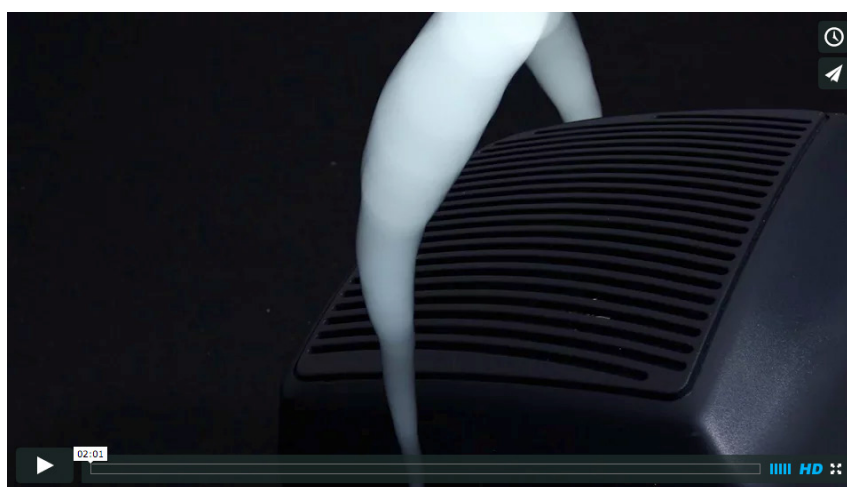
5 Conclusion

The project set out to identify and communicate an invisible aspect of our technological lives to a wider audience. To engage with the public as well as design, academic, scientific and engineering communities who might also find the research and approach valuable. Upon completing the project a two minute

video was created and uploaded to Vimeo.com and the majority of photographs (both successful and failed) were uploaded to a dedicated album on Flickr.⁴

The toolkit that was created for the purpose of the project has been shared as open-source code.⁵ Allowing anyone with programming experience to download, modify, improve, and ideally share their own learnings. To teach others and contribute to a wider public conversation. An iPhone and Android version of the mobile applications are available to download for free from the respective app stores.

Fig. 9 Visualising electromagnetic fields video (<https://vimeo.com/65321968>)



5.1 Digital sharing platforms

As well as documentation, both these platforms allow image and video content to be easily shared across the globe instantly. Using the internet, email, blogs and social media to share links and images that all link back to one another, provide a content loop that connects and maintains a link between the produced content, the research, written text, articles and press releases and perhaps most importantly, a digital record of the comments and discussion that took place online.

5.2 Creating dialogue

After only two months of being published online, the project was featured on the technology and lifestyle blog the *Creators Project*.⁶ The article was titled *Light Painting The Electromagnetic Field* and was written in response to the project, featuring the video, a selection of eight photographs and links to other 'related' projects and art; continuing the discussion and EMF and invisible technologies.

⁴ https://www.flickr.com/photos/luke_sturgeon/sets/72157633310156013/

⁵ https://github.com/lukesturgeon/iOS_EMF_Sensor

⁶ <http://thecreatorsproject.vice.com/blog/light-painting-the-electromagnetic-field>

We're surrounded by things we can't see. In a recent project the pair decided to make visible the electromagnetic field (EMF) that surrounds many of the devices we use in our daily lives. To do this they used long exposure photography and stop-frame animation to produce light paintings that show the EMFs that surrounds laptops and a old school tape deck. (Holmes 2013)

The first article was discovered by several other technology⁷, lifestyle⁸, news⁹, fashion¹⁰, design¹¹ and business websites¹² and since being uploaded to Vimeo on April 2013 the video has been played more than three-hundred thousand times and shown at film festivals and design events around the globe.

The phone was used as a kind of light brush, which reacted to the changing strength of the EMF, and long exposures allowed them to capture the whole field. Amusingly, the EMF from the laptop's hard drive was strong enough to stall the phone's magnetic sensor – so there's still room for improvement – but the result is pretty cool nonetheless. (Condcliffe, 2013)

The conversation and discussion that was provoked by the decision to publish the work on digital sharing platforms was one of the largest success points for the project. The aesthetic and technical decisions that led the the creation of images and stop-frame animations provided visual content that could be shared easily, and were used alongside provocative article titles such as "Your MacBook Has a Force Field. This Is What It Looks Like". This led to a series of conversations about technologies and phenomena that we can and cannot see, how we measure these things and how we visualise and express them. The conversations were provoked by the original work.

7 <https://www.prote.in/en/feed/2013/07/visualising-electromagnetic-fields>

8 <http://www.wired.com/2013/07/the-invisible-images-coming-from-our-favorite-devices/>

9 http://www.huffingtonpost.co.uk/2013/07/03/laptop-invisible-force-field_n_3541122.html

10 <http://www.esquire.co.uk/gear/gadgets/4279/laptop-electromagnetic-forcefields/>

11 <http://www.creativereview.co.uk/feed/july-2013/06/visualising-electromagnetic-fields>

12 <http://www.businessinsider.com/designers-make-force-fields-from-laptop-and-iphones-visible-2013-7?IR=T>

You might view your laptop as a nice, neatly contained unit – but there's more bursting out of it than meets the eye. In fact, all of its electrical components create complex magnetic and electric fields that spread far and wide, and this video shows you their reach. (Condcliffe 2013)

Though the images are beautiful, the information we can glean from them is still abstract. (Stinson 2013)

The phone was used as a kind of light brush, which reacted to the changing strength of the EMF, and long exposures allowed them to capture the whole field. [...] there's still room for improvement – but the result is pretty cool nonetheless. (Condcliffe 2013)

The images from the project focused on provocation and engagement instead of the accurate reading of numeric and

statistical information. They exist as a way to excite and provoke conversation.

5.3 Education

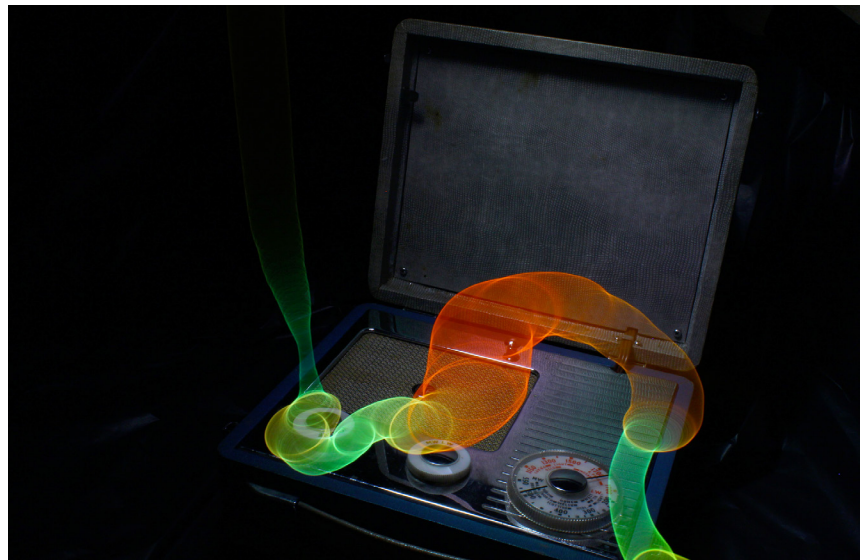


Fig. 10 Science Museum workshop participants

In September 2014 the Science Museum¹³ in London requested a participatory workshop building on the original concept in collaboration with the museum's own collection of everyday electronic objects that span decades of human invention and scientific discovery. The 1-day workshop provided hands-on experience for participants who were introduced to the photographic techniques and given access to an improved version of the EMF application that was created for the original project.

Participants of the workshop had backgrounds that ranged from photography, design and art to software engineering, social sciences and business strategy. They were paired and each given a camera, tripod, and photography station. Through hands-on learning and discussion they were able to develop thorough understanding of light-painting and electromagnetic fields within a few hours, producing over 300 photographs that were presented by each pair at the end of the day.

Fig. 12 Workshop participant results



In comparison to the original images, the photographic results from the workshop demonstrate a preference for playful expression rather than comparison and communication of invisible electromagnetic fields. However the participants were able to understand and then explore the material qualities of EMF, in order to achieve the expressive images they created.

The workshop concluded with a late-night public event held at the Science Museum. The results from the workshop were displayed alongside the electronic objects from the workshop and

¹³ http://www.sciencemuseum.org.uk/visitmuseum/Plan_your_visit/events/media_space_events/field_life_of_electronic_objects.aspx

¹⁴ <https://www.flickr.com/groups/secretlifeofeverydayobjects/pool>

a working camera setup, so that visitors could learn through hands-on demonstrations.

For us, the queue of visitors during the late night event was the measurement of success for the overall project. Through composed photography and careful consideration to the visual language and presentation of scientific phenomena we created intrigue, then understanding and dialogue. As well as facilitating discussion and conversation between visitors, through the presentation and explanation of the original concept, image-making process and motivations for the project.

The final work has been collected in a public Flickr group¹⁴ titled “The Secret Life of Everyday Objects”. This approach allows anyone around the globe to contribute their own work and participate in a discussion around invisible phenomena and technology. Using existing photo sharing platforms and social media to engage with a curious audience, regardless of expertise or available tools.

5.4 A new approach to visual data representation

The project has resulted in a better understanding and case-study for the engagement of a wider audience in the conversations around technology, design and science. Through the careful representation of information in an accessible and comprehensible visual vocabulary, open discussions can be achieved across discipline and regardless of technical experience. Provoking conversation and new work, through the collaboration of different disciplines.

Acknowledgements.

The original project was created at the Copenhagen Institute of Interaction Design (CIID) in response to a design brief set by visiting faculty Matt Cottam and Timo Arnall.

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Data Exploration on Elastic Displays using Physical Metaphors

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Keywords: elastic displays, information visualization, haptic interaction

Elastic displays empower users to interact naturally through pushing and pulling, folding and twisting. While this kind of interaction is not as precise as on other devices, it utilizes interaction metaphors which are easy to learn and understand. We present a system that uses physically based interaction and visualization metaphors to gain a deeper comprehension of the underlying data and its structure. By applying pressure on specific interface elements, associated items are attracted and repelled, the exerted force on the items itself translates into a semantic zoom behavior to display more in-depth information about the specific entity. We present the core concepts of the system, explain the decisions made during the design process and discuss the advantages and disadvantages of the proposed system as well as a short view on further improvements and open research questions.

1 Introduction

Interacting with complex visualizations is a common challenge. Faceting data, selection strategies and the visualization of correlations between data points result in complex user interfaces which lack intuitiveness and the option to explore freely without in-depth knowledge about the underlying concepts and data structures. A possible solution to these issues could be elastic displays which offer an additional dimension of interaction. Elastic displays that deform are a new field in Human-Computer Interaction. Due to their elasticity, these displays allow users to change the surface by pulling, pushing or twisting. Furthermore, elastic displays offer a unique interaction experience through haptic feedback. The elastic membrane may be imprecise when compared to a mouse, but offers a rich multi-modal feedback which facilitates interaction.

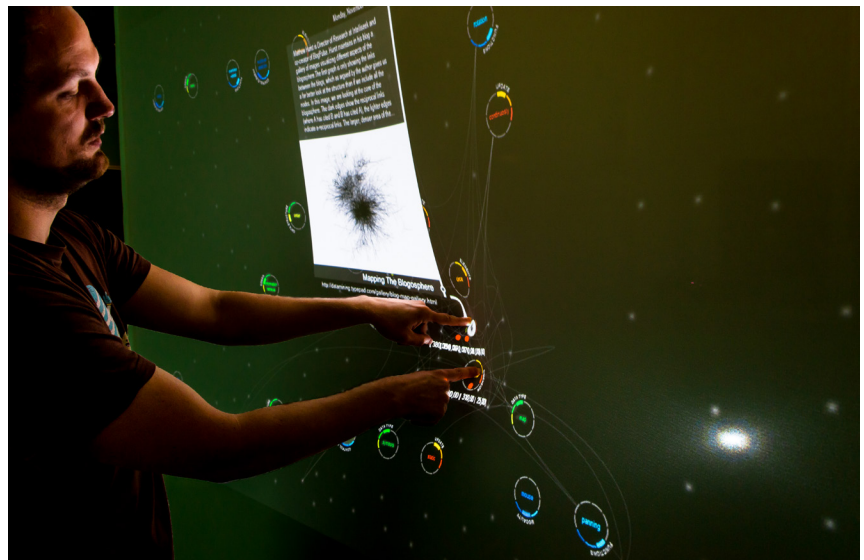
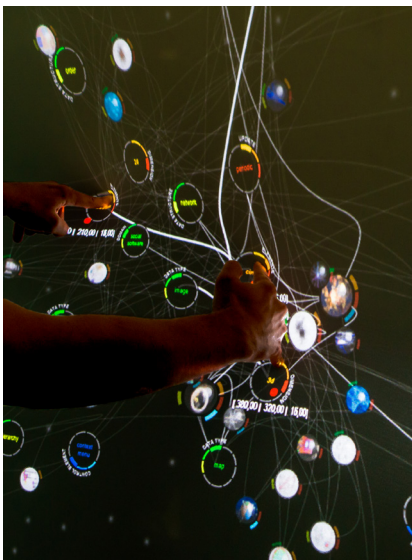


Fig. 1 Exploring different types of visualizations by pushing and pulling into the flexible surface

By extending the direct manipulation paradigm of touch interaction with a large range of different interaction states coupled to the pressure applied on the surface, elastic displays offer a rich and versatile interaction space. The deformation of the surface addresses one of the core problems with current touch devices – they offer basically the two states “on” and “off” for touch recognition. More fine-grained touch interaction can only be achieved with additional devices like pressure-sensitive digitizers or by utilizing the duration of the touch for emulating pressure. The first option is useful in many scenarios, but lacks the versatility of the human hand to form and execute different gestures and again puts a tool between the finger and the interaction surface. The second solution represents a rather weak, indirect substitute for real force sensitive surfaces.

With metaphors based on physical interaction, the interface can generate additional cues to understand the data and connections between elements of the visualization. We argue for using elastic displays to explore complex data sets. We present an approach on data from a database of visualizations using an elastic display called *FlexiWall*. The data is taken from the *DelViz* database, which consists of more than 700 different visualizations classified in hierarchically organized categories of keywords describing the content of the different visualizations.

The goal of this paper is to present a novel approach for playful and intuitive exploration of data sets using advantages of elastic displays.

2 Related Work

In the last years there has been a lot of research focused on elastic displays. *Cassinelli* and *Ishikawa* first published about an elastic display they called *Khronos* projector (Cassinelli and Ishikawa 2005). *Peschke et al.* describe an elastic display used as tabletop system (Peschke et al. 2012). In former publications, we classified suitable data types and interaction techniques, based on the experience of both *DepthTouch* (Fig. 2, left) and *FlexiWall* (Fig. 2, right; Franke et al. 2014). The transfer of multi-touch paradigms like gestures, tangible objects and their applicability in the context of deformable surfaces led to the definition of a design space for elastic displays. Gestures and other interaction techniques like gravibles or geometric shapes are introduced in it (Gründer et al. 2013).

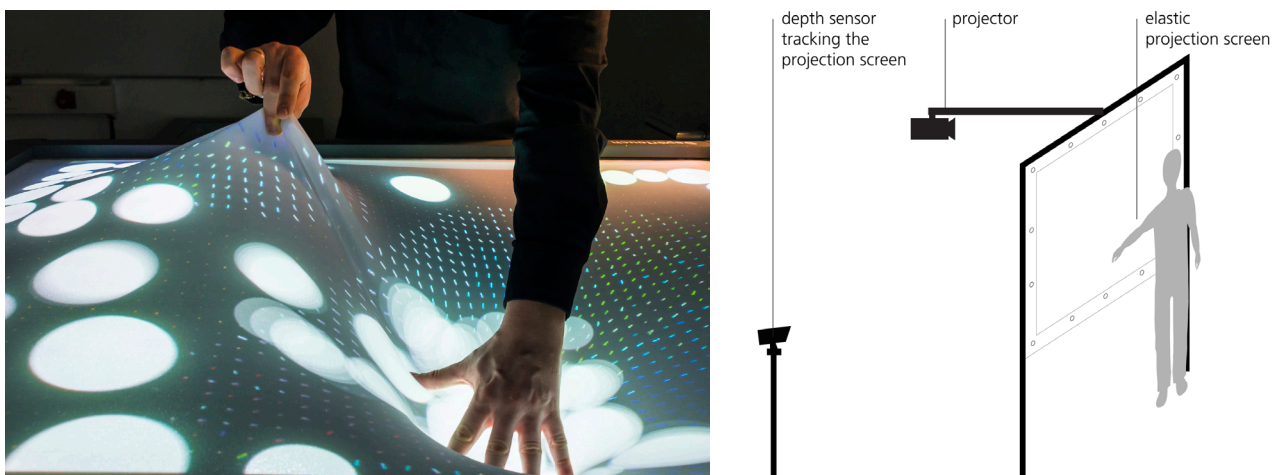


Fig. 2 The DepthTouch prototype in action (left). Core components and system setup of the FlexiWall prototype (right).

Troiano et al. identify gestures used on elastic displays by utilizing the guessability studies method. They find that grab and pull, push with flat hand, grab and twist, pinch and drag and push with index finger are the gestures used most often for the interaction

in depth (Troiano et al. 2014) Regarding solutions for common technical issues with elastic displays, Watanabe et al. describe solutions to the projection and warping problems occurring while pushing or pulling the membrane (Watanabe 2008).

Due to the prototypical character and the easy setup, elastic displays have been used in the context of artistic installations and demonstrators, which facilitate playful exploration. Examples for artistic installations are *Cloud Pink* and *Soak, Dye in light* from *everyware* (everyWare01, everyWare02) and *firewall* from *Sherwood* (Sherwood 2012). Use cases apart from the scenarios are described in (Gründer et al. 2013), (Sterling 2012) and (Cassinelli and Ishikawa 2005). One of the rare works describing data visualization on elastic displays is the *ElaScreen*, which utilizes an elastic display system for graph navigation scheme (Yun et al. 2013).

The presented work is based on the *DelViz* system (Keck et al. 2011). They classified data visualizations from the *visual complexity* (Visual Complexity) collection with a faceted approach. They then describe the multi-touch exploration software with focus on the connection of facets and visualizations. As one of the core advantages of elastic displays is their haptic nature, we decided to follow the concept of physically-based interaction by Jacob (Jacob et al.) to mediate correlations of objects and interaction with the visualization. An example for concepts from physics applied to interaction can be found in (Agarawala and Balakrishnan 2006). They describe a system based on physical metaphors. They present a 3D visualization of Desktop Icons. The icons are influenced by physical interaction with a pointer. The pointer is able to grab and throw the icons around.

3 Interaction Concept

We chose to use the *DelViz* classification of visualizations. Every visualization type is described by a set of metadata such as a short description, title, web link and the date it was added. The visualizations are associated with a number of tags representing the most important properties. These keywords are based on three main categories: *Data*, *Visualization* and *Interaction*, and their associated dimensions (Fig. 3). The tags in the dimensions are competing terms to which the items are matched. However they are not mutually exclusive, e.g. visualizations can combine text and *images*, address both *science* and *economy* domain or employ scrolling as well as *Overview/Detail* functionality. There are complex relations between the items based on their associated tags.

The relations are formed by the items they are assigned to. If items are tagged as *2D* and *static*, those two have a connection. The user is able to filter by several tags or deselect them in order

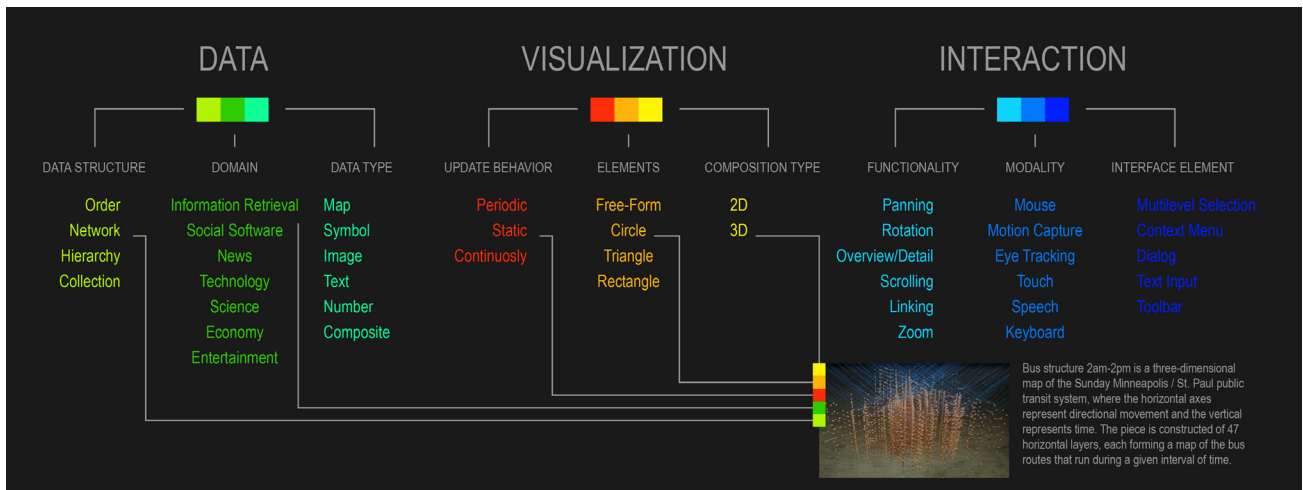


Fig. 3 The *DelViz* classification schema and associated colors used in the prototype with example visualization, associated tags and description (bottom right).

to explore the dataset. According to the selection items are highlighted or diminished. The dataset contains of few major tags, like *2D* or *Network*, which are associated with about two thirds of the items. Other keywords are assigned to only a handful of items, what implies a rather unbalanced tag distribution. The goal is to search and identify visualizations matching given properties, represented by their associated tags. The core concept is to explore items based on weighting several tags. The concept used for the prototype described in this paper originated on the work about the *DepthTouch* (Peschke et al. 2012).

One of the applications of the *DepthTouch* was a simple physical simulation – spheres projected on the surface reacted to the deformation by moving according to the resulting gravitational forces of the deformed surface (cf. Fig. 2). Observations of users show that interfaces based on easy physical concepts like gravitation, mass, spring forces or force fields are playful, easy to understand and to learn. Once people push the surface, the immediate haptic and visual feedback helps to quickly form a mental model of how the interaction works. In contrast to e.g. stacked images which are selectively blended according to the deformation, which require the user to associate the deformed surface to abstract data or image layers, this “natural” reaction to the actions of the user is immediately recognized and interpreted correctly. Users immediately know which actions they have to undertake to achieve a specific goal (e.g. to split a group of spheres by creating “holes” on two opposite sides of the group) because they are used to these simple physical principles from daily life. Therefore our implementation is based on the concept of simulating physical forces to interact with a set of items. The core idea is that for exploration of large data sets filtering and grouping of objects represent basic tasks that can be translated into a simple physical simulation, which allows it to collect objects by pushing into the depth and separating items by creating peaks in the elastic display.

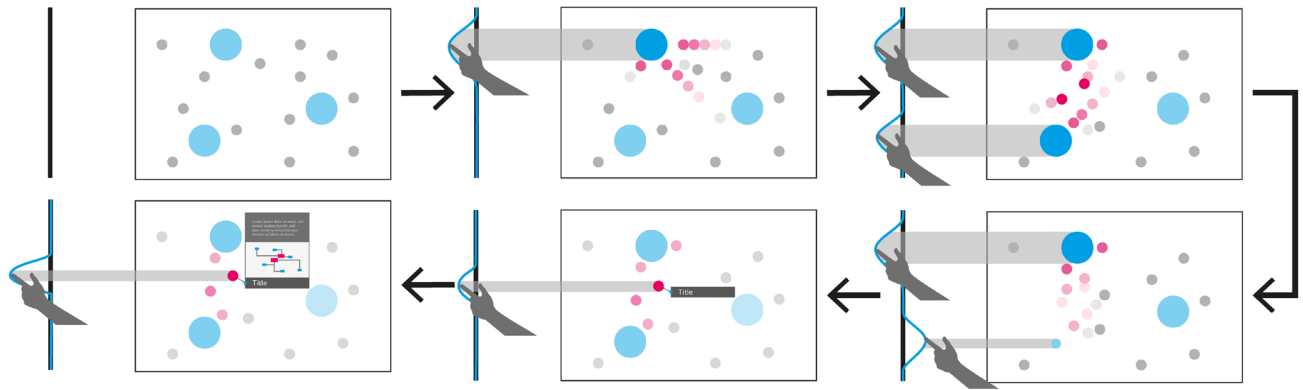


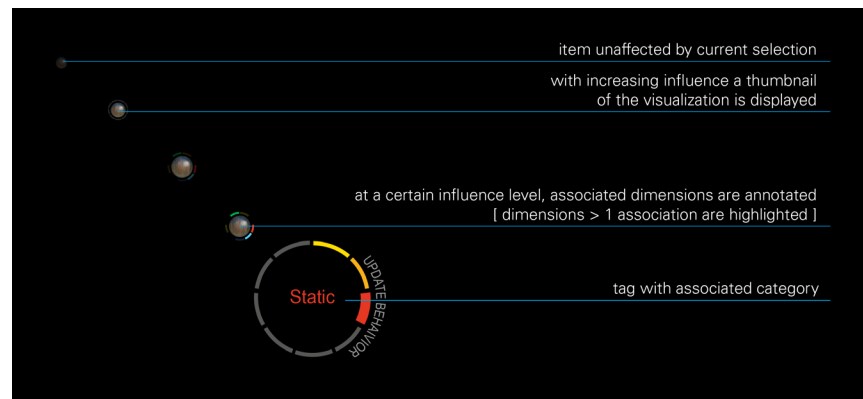
Fig. 4 Tags (blue) and inactive items (grey) are floating on the surface (top left). When pushing a tag into the surface, it attracts associated items, which change their shape to show a thumbnail of the associated visualization (top middle). When two tags are activated by pushing into the surface, associated items are moving toward the gravitational center (top right). Pulling the surface towards the user pushes away and deselects associated items (bottom right). Details about the visualization are displayed using a semantic zoom: the more pressure is applied the more information is shown (bottom middle and left).

Transferred to the *DeIViz* scenario, the tags of the dataset represent gravitation centers. Items have “natural” repulsion which prevents them to be influenced by the tags in their normal state. However, when pushing into the surface at the position of the tag, its gravitational force will be increased according to the applied pressure and all associated items are attracted by it. They do not just appear next to the tag but make their way to it. The movement not only indicates the association but also the strength of this association represented by the movement speed of an item. This way the user can tap tags and observe which items are connected. Additionally to the changing movement, the items’ representation contains a thumbnail of the associated visualization item and additional information about associated categories. Thin lines represent connections to other tags. Pulling the surface towards the user reverses this force, so that items are pushed away (Fig. 4, second image) and fade out. By applying different pressures to several tags, items are filtered and concentrate around the area next to the gravitational center of all manipulated tags. Items only belonging to one tag will move towards it. Items attracted to more than one gather in their center (Fig. 4, third image). The interaction is based on simple push and pull. Filtering is achieved by applying different gravitational forces to the tags, while the visualization of detailed information and connections between tags and content are retrieved by activating an item. An item again is activated by pushing into it. Items attracted to tags get an image depicting the visualization they stand for, so the user knows that these items can be selected. Fig. 5 depicts the combination of possible states for items.

The presentation of information for each item follows the principle of a semantic zoom. Depending on the amount of pressure applied more or less information is displayed, starting from displaying the title of the visualization and its connections to other tags. Applying more pressure reveals a larger image the visualization and finally additional context information about the visualization, like the description or the associated web address is

displayed (Fig. 4, last 2 images). The same accounts for tags. The more pressure is applied, the faster are associated items accelerated towards it. If a pull is affecting a tag, associated items are repelled from it.

Fig. 5 Different representation of items according to the strength of the force applied to the associated tag.



4 Design Process

One issue with elastic displays is associated with the question how to motivate the user to touch the screen and push, pull or somehow deform it. Based on observations with similar systems, this represents a critical point. Once users have interacted with the system or observed other people how they used the display, the core concepts of the system should be quite easy to understand and become accessible by playing with the system. However, offering affordances for touching and deforming of a screen is quite a difficult task, due to contrasting experiences of users in current systems. We decided to offer subtle signs for interactivity – the items are constantly moving and from time to time specific items start glowing, revealing parts of the connections to surrounding tags. Although this behavior only partially solves the problem of users staying away from the surface, it provides clues how to interact and should arouse curiosity about the system.

Another challenge was to create the physics system for the simulation of item and tag movement. We wanted to create a rather simple system, which feels authentic to the user when interacting with the system. However there are a quite large number of constraints resulting in a number of system parameters which had to be balanced out to guarantee a certain stability and self-recoverability of its initial state after interaction took place. The system basically computes two types of forces between items which are based on their semantics:

(1) Forces between tags: tags sharing a large number of items attract each other. Additionally, Tags belonging to different dimension are pushed away.

(2) Forces between items: As mentioned above, items are pushed towards active associated tags or their gravitational center or pushed away, if the tag is pulled out of the surface.

To prevent the system from getting into a stable state, where tags and items do not move anymore, we added small centripetal forces of random speed to each item. Additionally, the direction is modified randomly to achieve a steady, slightly chaotic flow of the visualization. Collision is based on forces degrading over distance between objects. Similar collision forces prevent items from leaving the screen and push them constantly towards the center. As we wanted to create a flexible system, which acts independent from the visual representation and can also be configured for different associated data sets, these forces need to scale with or adapt to the number of items and tags, the size of their graphical representation, screen size. It is easy to change parameters at the start of the simulation, like object size and intensity of applied forces. Some parameters can also be changed dynamically during the simulation, which enables a wide range of possible effects and visualizations for different aspects of the system.

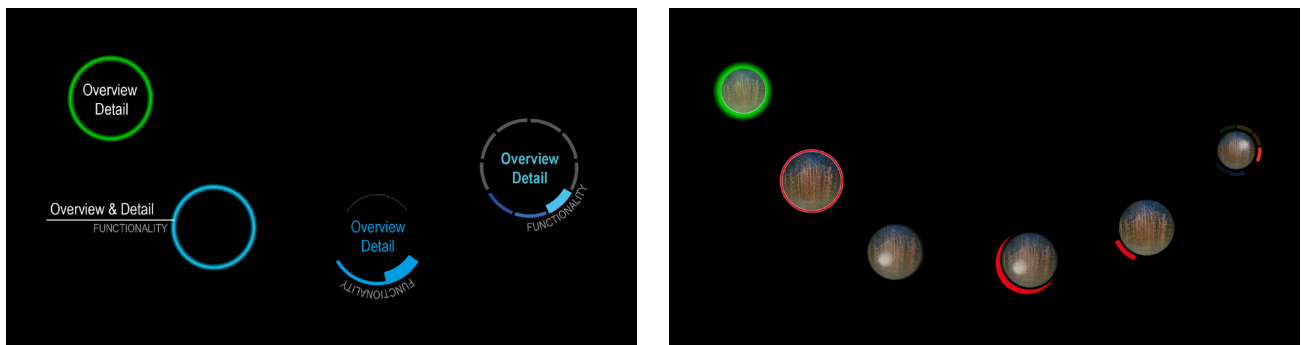


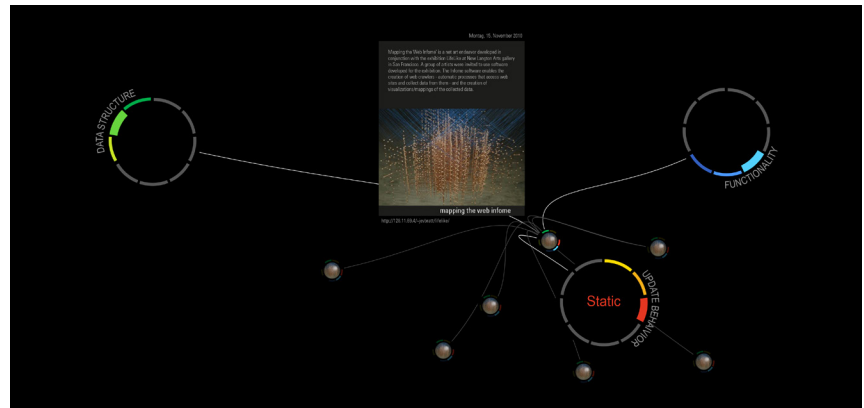
Fig. 6 Design iterations of Tags (left) and visualization items (right). Rightmost items represent the final versions of the item.

The design of tags and visualization items followed the idea of gravitational forces between objects. As forces are acting equally in every direction, the decision to use circles or spheres to represent objects was obvious. However, the question was which information should be displayed on the tags or the items. Tags are associated with a color representing the associated data dimension (cf. Fig. 3). We decided to select three categories for each dimension. As a result, we get nine possible categories a tag can belong to. In the final design, a tag is represented by a circle consisting of nine segments representing the categories. Categories of the associated dimension are drawn in their respective color, other categories are greyed out. The associated category is drawn with a thicker line, its name written outside the circle. The tag name as most important information is written in the center of the circle (Fig. 6).

The representation of items follows the same pattern: The visualization is depicted by a circular thumbnail, surrounded by

circle segments representing tag categories, this item is associated with. If an item is associated with two or more tags of a category this segment is drawn in a solid color, in case of one tag it is semi-transparent, otherwise the segment is not drawn at all. The idea behind this visualization is that the user can identify similar visualizations by their characteristic layout of surrounding circle segments (Fig. 5, Fig. 6).

Fig. 7 Display of full details for a selected visualization, including a larger image, metadata and connections to other tags.



The final design also incorporates connection lines drawn from active items to their associated tags (Fig. 7). The idea is that the user gets a fast impression, which tags are relevant for further filtering of items: If a tag is not connected (or only connected by a few lines) with currently active items, pushing these tags will not further diversify the selected set of items. Lines are stronger if an item is connected to multiple selected tags (Fig. 1, right image).

5 Framework

The technical setup of the prototype consists of a standard Windows PC running the application, a large elastic fabric used for back projection, a projector and a Microsoft Kinect as depth sensor. The Kinect is positioned next to the projector and tracks the surface. Each point in the depth image delivered by the Kinect is projected on the associated point of the fabric. The interaction with the elastic surface completely depends on the tracking information delivered by the Kinect, as no other sensing technology is involved in the system (Fig. 2, right image).

We extended our existing *FlexiWall*-Framework (Müller et al., 2014) to achieve a precise tracking of surface deformations. The former implementation of the depth interaction followed a simple principle: Data was organized into several layers and the depth image delivered by the Microsoft Kinect was transformed into a greyscale image, where every color tone represented a specific depth value. Based on this texture, a pixel shader blended the different data layers into each other. As this happened frame by

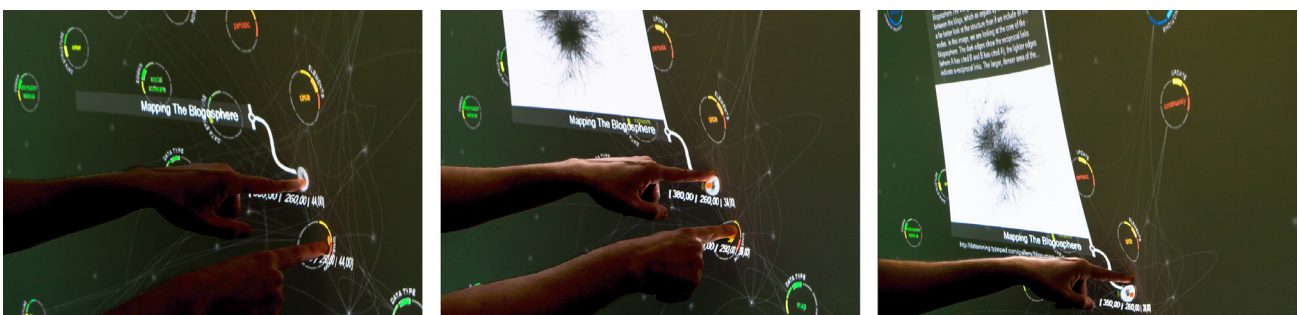
frame, the visualized image responded seamlessly to deformations. As the texture blending is done on the graphics card, this approach is fast and accurate. The problem was that the interaction heavily depends on image content. Only the depth direction was interactive. So it was not possible to drag items over the surface or rearrange things.

The current implementation includes a basic finger tracking, based on the deformation of the surface. The system does not support detection of touch; all computations of physical forces rely upon accurate information about local minima and maxima formed by the current shape of the surface. These are reconstructed by computing the partial derivatives of the depth values in horizontal and vertical direction. For performance optimization purposes, a down-scaled version of the depth image is used for the derivatives.

6 Discussion

The presented system represents a new way of exploring large and extensive data sets by applying a basic physical model as manipulation technique. Facilitated by the possibility to use the deformation of the fabric to sculpt the interaction space, exploring the facets and their content generates a playful experience. On the technical side, the system itself is sometimes lacking in terms of responsiveness and suffers from the small resolution of the Kinect sensor and artifacts resulting from the down-scaling of the depth image which results in a loss of precision for deformation reconstruction. Smoothing the minima and maxima as well in position al and temporal domain does help to increase the accuracy, but at the same time reduces responsibility of the system. This does not severely affect the interaction when selecting tags and filtering entities. However, pushing items to reveal detail- information and stepping through the different semantic zoom states (cf. Fig. 8) can be inconvenient, due inaccurate position detection and tracking lags.

Fig. 8 Semantic zoom for displaying visualization details: when pushing slightly, the name is shown. Applying more pressure the associated image pops up and the description is revealed.



However, most problems are compensated by the additional interaction dimension, which makes it extremely easy to adjust results even if you have to recover a former state after a tracking error. The concept focusses on playful exploration and basic selection tasks which suits the rather imprecise but intuitive interaction style. Users easily learn the concepts of the system by playing with it – due to its reactivity and limited feature set. As the current implementation recognizes a fair amount of local extrema, collaborative use is another feature (or even requirement, depending on the complexity of the data set) of the elastic surface. As selecting or deselecting three or four tags at the same time is difficult for one user alone and due to the dynamic of the system, the elastic surface necessitates collaboration for complex selection or filtering operations.

7 Lessons Learned

As the technical basics for the *FlexiWall* and its predecessor, the *DepthTouch*, are nearly equal, the application can be deployed for both systems. However, the orientation of the interactive surface plays an important role. As the *DepthTouch* is a Tabletop with an elastic surface, one problem of the current implementation is the orientation of the title and the objects description. People interacting with a Tabletop usually stand around the table, so displaying text is problematic when the position of the user is unknown. The *FlexiWall* as vertical screen benefits from its inherent bottom-up orientation. Text orientation does not represent an issue here. On the other hand, the concept of gravity may be easier to understand on a tabletop, as the pushing and pulling direction coincides with its direction. Therefore, the abstraction of forces between objects can be easier deduced from the natural direction of gravity.

Material stiffness and size of the elastic surface are further points of interest. Interacting with the large fabric on the *FlexiWall* deforms the whole surface. Fine adjustments or pushing/pulling objects nearby are difficult due to the size of the projection area. A stiffer material helps to increase positional accuracy and reduces the influence on other points. This has an impact on the collaborative use, as small interference between different locations of deformation allows more users to interact with the surface simultaneously and therefore more complex filters to be created.

Observations of test users show that one often demanded feature is the opportunity to preserve distinct states, e.g. save the current deformation to select additional items, or retrieve detail information of all currently selected items without losing the

current configuration of tags or items. The core idea is quite obvious, but the consequences are extensive: As state of the physical surface cannot be reserved (or restored later), saving the virtual state breaks this strong connection between the physical display surface and the forces based on its deformation. The question arises whether such a system is still easy to understand, and how large the differences between physical state and virtual state can become, before the user cannot link visual representation and physical/haptic experience anymore.

In combination with demands to save internal states, users often also mention dedicated gestures to trigger complex actions, system command or execute special operations on the data set. The diversity of possible gestures on and with the surface (twisting, bending, flip, bi-manual gestures, speed and size of gesture) offers many options for gestures. Possible (simple) gestures include wipe- gestures to put items to the side or pinch-like gestures to zoom into the visualization. However, these gestures again represent another level of abstraction and have to be learned before being usable. Although gestures add expressiveness to the system, its increased complexity limits the intuitive, playful use of the system.

As mentioned in section 4, the problem of the “first encounter” remains unsolved. Providing affordances for touching and pushing the surface may require physical extensions of the screen. One idea could be magnetic handles (e.g. made of semi-transparent plastic) which are attached to the elastic surface.

A more technical issue is the correction of the image distortion resulting from deforming the screen. While this distortion is not really annoying the users interacting with the system, the discrepancy of visual representation and tracking position poses a severe problem, especially when interacting with items located near the border of the screen.

A final observation relates to the response time of the physical simulation. We decided to break the physical rules at certain points to ensure a fluent interaction. Once selected, Tags remain on their position until the user releases them. The same applies to the selection of content items: Is one of these selected the whole simulation is stopped. These two adjustments are needed to introduce a time delay when the system recognizes a deselection of an object. In order to simplify the recovering from tracking errors, forces on objects are reduced for a small amount of time, so that the user can easily reselect an object if he or the system loses track of an item.

8 Conclusion

In this paper we presented a system to explore faceted data like the *DelViz* data set. As an interaction device we use the elastic displays *DepthTouch* and *FlexiWall*. The advantages of these elastic displays are the haptic feedback and intuitive interaction techniques. Typical gestures like pushing and pulling the fabric are used to select tags and data items, which react corresponding to the underlying physical simulation. Items are attracted or repelled and thus allow a fast understanding of the data and its structure by recognition of movement patterns. The amount of force used on the elastic membrane directly translates to force in the simulation. The more pressure is applied; the stronger tags and items react to each other. Additionally the items present more information as force is used to zoom semantically into items. Further on we discuss the technical properties and problems of the system. It allows fast interaction and comprehension, but lacks the precise detection of movement and discrimination of proximal touches.

We will try to keep the interaction as simple as possible and mainly work on detection and aesthetical problems in the near future. We want to incorporate technical improvements for more precision and try advanced algorithms for better tracking. Afterwards we would like to conduct user studies to validate the exploration concept and especially the advantages and disadvantages of the system.

Acknowledgements.

On behalf of Mathias Müller this work has been funded by the German Federal Ministry of Education and Research (project no. 16SV7123).

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Modelling Media, Reality and Thought: Ontological and Epistemological Consequences Brought by Information Technology

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Keywords: computational media, information technology,
ontology, philosophy, third culture.

Computers are our ultimate modelling machines. In the last decades, they became our first “metamedium”; the foremost means through which we generate, store and exchange media, but also our primary instruments for thinking. As a consequence, these “quintessential” products of information technology forever altered the way we think about reality, the world and ourselves. This paper argues our limited understanding of such transformations is one of the major impediments for developing adequate descriptive models for computational media. By showing how information technology is “re-ontologising” our world and stimulating a “permanent beta” attitude within contemporary technological culture, this paper shows that, without an adequate reformulation of our ontological commitments, our future analyses of media will be significantly hindered. By focusing on the metaphysical implications of current technological development, this paper shows the often neglected overlapping between philosophy and media analysis, but also the theoretical benefits of promoting it.

1 Introduction

In less than four decades, computers, the “quintessential information technology product” (see Floridi 2009) went from being highly specialised tools to become multi-purpose instruments present across every conceivable area of human activity. Having a seemingly endless range of applications, computers turned into our foremost “intellectual tools” (see Dyson 1997) and “media machines” (Kay and Goldberg 2003). As such – and to paraphrase Lev Manovich (2013), they have “taken command” of virtually all forms of communication and representation, thus becoming our first *metamediums*. Through this ‘digital revolution’, technology at large has been recognised as a crucial factor for social and cultural change and even embraced as a form of culture in and *for* itself (see Kelly 1998). Within this ‘post-digital’ setting, understanding contemporary media implies analysing the contents, reception and social effects of audio-visual communications, and understanding the history, functions and idiosyncrasies of the instruments responsible for generating them. Given the constantly evolving nature of information technology and the profound ways in which it has transformed our view of the world and ourselves, this is far from being a simple task.

Over the last decade, media analyses experienced important changes. While Bolter and Grusin’s (2000) *Remediation* still remains an even tempered response to the hype sparked by ‘new technologies’ – in particular the early prefiguration of Virtual Reality (VR) – their overall analysis ended up reducing ‘new media’ to little more than “refashioned” representations of traditional media. In contrast, pragmatist models began to shift their focus away from the contents and discourse of audio-visual representation and towards their technical aspects and history (see Kittler 1999; 2009). Unlike the dominating traditions within the humanities, these approaches no longer dismiss the possibility of technological autonomy and agency as ‘deterministic’ ideas. More to the contrary, they belittle the humanities’ traditional disregard for technical knowledge (see Fuller 2008) – in particular of programming – and advocate for incrementing our overall computational literacy (see Mateas 2005; Hayles 2002), and for the recognition of software as the new dominant medium (see Manovich 2013). Finally, influenced by the philosophy of technology and video game studies, new transdisciplinary models are beginning to explore the relationship between computational technology and philosophical analysis (see Bogost 2012; Gualeni 2014), concentrating on the metaphysical problems brought about by computational tools and media.

The fact that computational technology became our primary information medium – that is, the foremost means through which we generate, store and communicate our *thinking*, has deep epistemological and ontological consequences¹. This paper argues that our limited understanding of those consequences and their implications constitutes one of the major impediments for developing effective descriptive models for contemporary media. Following Luciano Floridi's (2010) description of the "information revolution", Kevin Kelly's (1998) portrayal of the "third culture", and various accounts belonging to the philosophy of technology, this paper will describe some of the most salient ontological and epistemological changes introduced by computational technology. The analysis begins by arguing why information technology is effectively "re-ontologising" our world, before making the case for why our traditional approaches to computational media have failed to recognise these metaphysical shifts. Finally, the analysis closes by showing why, given its role as our very first intellectual *metamedium*, the computer has become our ultimate modelling machine. The overall, theoretical implication stemming from this analysis is that – without an adequate reformulation of our ontological commitments – it will be increasingly complicated to generate adequate critiques of computational technology and media.

¹ The most obvious being that we now conduct most of our thinking through the very instruments we are attempting to describe.

² According to Kevin Kelly (2010), the only classical treatise where the construction *technelogos* appears – albeit only a handful of times and with a rather unclear meaning – is Aristotle's *Rhetoric*.

³ Even Vannevar Bush (1945), in his influential article, *As we may think*, refers to his imaginary artifacts as "machines" or "instruments" and not as 'technologies'.

⁴ A quick search in Google's *Ngram Viewer* shows that before the 1920s the term is virtually inexistent. In the following decades its usage experiments a steady growth until 1952, where the curve shows a dramatic surge.

⁵ The rather nebulous term 'new technologies' is a telling example of such tendency.

2 Technology's role

The word 'technology' is nominally Greek², but the concept itself is a (relatively) recent invention. Johann Beckmann, a German professor of economics who realised the tools and techniques used by all trades were not a haphazard collection of unrelated artefacts, but elements of an interconnected *system*, coined the term *technologie* in 1802 (see Kelly 2010). Despite the importance of such finding, both the newly minted concept and the systemic nature of technology would remain obscure notions³ for the following 150 years⁴. The resurgence of the term coincided more or less with the dawn of the 'computer age'; a circumstance that may partially explain why, for many media scholars, 'technology' was (and still is) synonymous with computational devices. Being a "functional category" (Levitin 2014) technology refers to all sorts of artificial devices and techniques, but the 'technology ≈ computer' equation continues to resurface every now and then in contemporary media analysis⁵. This incidence cannot be attributed solely to some media theorists' reluctance to clarify what they mean by technology, but to the inherent haziness of the term and the multifarious nature of the phenomena it refers to.

Devising tools is an intrinsically (although not exclusively) human trait; we have been doing it for over three million years

(Wong 2015), and it would be difficult to dismiss its importance for our evolutionary success. It is precisely this role and how it relates to 'culture' at large what makes the definition of technology such a complex problem⁶. Cultural and technological change are quite difficult to trace, and establishing which one exerts more influence over the other at any given time is equally troublesome. For the critical theory and cultural and literary studies traditions, there is little point in attempting to do so, since, in their views, technology is but a manifestation of culture. Consequently, they dismiss any suggestion that technology might be an autonomous agency capable of inciting social change without direct intentional involvement of a human subject as a "deterministic" (Bolter and Grusin 2000; see also Dusek 2006) or "reductionist" idea. That technology has indeed agency and is well beyond human control are precisely the views of thinkers such as Friedrich Kittler (1999; 2009; Gane 2005) and Kelly (2010). For its part, middle-ground positions between "cultural determinism" (see Dusek 2006) and 'technological determinism', portray technologies as "hybrid" systems (Ihde 2009; Latour, 1993) comprising "hardware" (tools and machinery), "software" (institutions, ideas, customs), and the agents that apply them (see Dusek 2006; Li-Hua 2009). Under this view, potentially "every creation system beyond the basic apparatus of the body" (Wilson, 2009, 9) qualifies as technology.

With the arrival of the PC, Internet, mobile communications and other information technologies, humanity thrust itself into a *revolution* (Floridi 2010) with profound cultural, social and philosophical consequences. In terms of aesthetic creation, the evolution of mainframes into "media machines" (Manovich 2013; Kay and Goldberg 2003) brought about a significant shift in the way we produce and understand audio-visual communications and art. Software's 'ability' to simulate most previously distinct physical media *and* its tools (Manovich 2013) calls into question the adequacy of the 'medium' as a descriptive category. With digitisation came the inevitable loss of materiality; and theoretical approaches that relied on the 'objectness' of aesthetic artefacts found themselves engaging a new form of presence. Overall, the introduction of computational devices implied that aesthetic analysis would have to engage technology from a theoretical standpoint and assume that this dimension of cultural production could not continue to be ignored and treated as an alien province reserved for science and engineering.

⁶ For a more complete overview of the various definitions of technology see: "Dusek (2006), Verbeek and Vermaas (2009) and Ihde (2009)."

3 Theoretical approaches to 'new media'

Heavily influenced by the critical theory and cultural studies traditions, early analyses of computer-generated media tended

to focus solely on their hidden dynamics and possible social effects, while disregarding the technical conditions which bring them to life. Amongst the most well known accounts stemming from this tradition is Bolter and Grusin's (2000) "remediation"⁷ model, which essentially claims that there is no meaningful difference between traditional (electronic) and so-called 'new media' because both constitute 'remediations' of previous forms of representation. In their view, new media is but a "refashioning" of old media and therefore shares the same goal as all forms of representation since the Renaissance: to "put the viewer in the same space as the objects viewed"⁸ (Bolter and Grusin 2000, 11) while simultaneously concealing the factuality of their intermediation.

Other models focus instead on the "material structures" (see Gane, 2005) – i.e., on the tools – responsible for generating media. Unlike their content-centred counterparts, these approximations no longer regard the idea of technological agency as anathema. Their views can be traced to the pragmatist tradition, particularly, the notion that theory and practice work together⁹ (see Haack 2003) and, consequently, that our knowledge of the world is mediated by our instruments as much as by our concepts. Friedrich Kittler (1999, 2006), a vocal critic of "anthropocentric"¹⁰ interpretations of media, was perhaps one of the most influential figures within this 'camp'. He believed that technology ought to be critically analysed (see Gane 2005) precisely because it is increasingly beyond human control. Kittler's overarching arguments portray media technology not just as objects of representation, but also as mediators of information. His approach consisted in understanding media by analysing the historical and technical conditions that surround their production.

For its part, software studies – a relatively recent tradition, which advocates for a richer understanding of the history and idiosyncrasies of computational technology, tacitly endorses technological agency while it chastises the humanities' for their insistence on dismissing the importance of programming and computational culture. More or less in the same tone, scholars such as Michael Mateas (2005) and Matthew Fuller (2008) argue 'procedural' knowledge should not be regarded by the humanities as the exclusive domain of science and engineering, but embraced at large as a new form of literacy. As a theoretical approach, software studies aim to understand contemporary media through the specific technology responsible for generating it. Subscribing to the views of early personal computing pioneers, they regard the computer as the first "metamedium" (see Kay and Goldberg 2003; Manovich 2013) and software itself as the indisputable 'place' of contemporary media creation. Contrary to the remediation approach, they do recognise a fundamental distance between

7 Which they admittedly built upon McLuhan's (1994, 8) claim that the "content" of any medium is always another medium".

8 Which, to a certain extent, is a rehashing of Heidegger's claim that the invention of the radio answered "man's existential tendency to 'de-distanciate', to diminish distances" (Kittler 2009, 29).

9 Because, in their view, the meanings of concepts become clear *precisely* as a result of their practical implementation, otherwise, they remain ungraspable abstractions. For pragmatists, models that dismiss the active role of practice (and hence, of technical instruments) are inherently suspicious (see Haack 2003).

10 He was particularly critical of McLuhan's portrayal of media as "extensions" (see Gane 2005, 28).

traditional and computational ('new') media. They argue that the constantly evolving language of contemporary audio-visual artefacts is symptomatic of software's idiosyncrasies, in particular, of its ability to simulate virtually all previously distinct forms of media, their tools and techniques (see Manovich 2013).

Although philosophical speculation on technology has been more or less present for various centuries, it was not until the 1970s that it became fully recognised as a particular branch of philosophical inquiry (see Dusek 2006) – whether the rise of computational technology played a significant role in this process or not is a matter open to speculation. For philosophy, computers are deeply transformative devices, not only because they played a fundamental role in the development of contemporary theories of the mind (see Pinker 1998), but also because the prospects of attaining AI and VR have serious implications for most long-standing philosophical areas. In particular for those concerned with existence, knowledge, life, mind, and ethics. The philosophical outlook on computational technology has attracted the attention of various media and video game scholars (see Bogost 2012), given that many aspects of programming and information systems deal with metaphysical problems and this, evidently, is a distinctively philosophical area of enquiry. Moreover, this interaction has given rise to various forms of cross-fertilisation leading scholars to regard computational technology as useful appliances for conducting philosophical research (see Gualeni, 2014).

4 A conceptual framework

4.1 The third culture

Over the last decades, technology has not only been recognised as a defining aspect of human culture but – as Kevin Kelly (1998) would argue – as a form of (pop) culture based on technology and *for* technology. Kelly describes this “third” or “nerd” culture as an “offspring of science” which, unlike its forefather, does not seek to discover ultimate truths about the Universe but generate “experience and novelty” through technological development. Although by no means a fully-fledged descriptive model, Kelly’s characterisation offers a thought-provoking basis to describe not only the social consequences of widespread technological adoption but also – more importantly – the epistemological shifts that accompany it. Kelly credits C. P. Snow (2000) with already having described a middle-ground culture capable of bridging the gap between the two supposedly irreconcilable cultures described in his (infamous) lecture. Kelly, however, loses the moralising tone and modernist idealisations that pervade Snow’s work, and

describes this cultural tendency as an overlapping of scientific and engineering outlooks fuelled by an unrestrained desire to generate experiences – an attitude which, we should note, closely resembles vanguard’s artistic experimentation. As described by Kelly, the third culture is rather indifferent to theoretical restrictions, boundaries and credentials. Consequently, it favours ‘trans-disciplinarity’ and ‘remixability’, and is willing to embrace “the irrational” (Kelly 1998) if it holds the promise of a new experience. In order to solve a problem members of the third culture would rather build a functional artificial *model* than come up with an abstract theoretical solution for it.

4.2 Information technology

By definition, History begins with writing, and writing constitutes the first means to *register information* as “non-biological memory” (Floridi 2009, 227). It follows that writing marks the first stage in the evolution of information technology (IT) and thus, the dawn of the ‘information age’ (see Floridi 2010). IT has three main functions (Floridi 2009): to register, communicate and generate information; and each of these functions has dominated the various stages IT has gone through over the millennia. Contrary to what some analysis of media stipulate, with each novel iteration, IT does not *replace* its previous incarnations, but rather *incorporates their functions*¹¹ – neither analogue, nor digital audio-visual technologies have made writing obsolete. In the last three decades, computational technology has been steadily incorporating all the functions that were previously scattered throughout various dedicated technologies and, in the process, generating new ways to carry out those same functions. The computer thus constitutes the quintessential IT appliance (see Floridi 2009). As far as functional categories go, ‘information technology’ is no less nebulous than ‘technology’ alone; after all, the former harbours everything from handwriting, to a magazine or a social network. Nonetheless IT does indicate what is the practical and historical *common denominator* shared by all the entities it refers to, and what their general functions are. It follows that both computers and ‘media’ (whether analogue or digital) can be described in general terms as IT.

4.3 Ontology

¹¹ It is fair to remember that McLuhan (1994) as well as Bolter and Grusin (2000) have commented on this idea.

As a specific branch of philosophy, ontology is concerned with ‘what there is’ (Floridi 2004). To paraphrase Barry Smith (2004), ontology is a fundamentally descriptive enterprise concerned with types, kinds, structures, properties, events, processes and

relations amongst entities, and with the various interpretations of reality; it involves “exhaustive classification” and *categorisation* within “all spheres of being”. Unlike science, ontology does not seek explanation or prediction, but *description*. Ontology is a core element of metaphysical analysis (often both terms are treated as interchangeable) and its preoccupations sometimes overlap with those of epistemology – which is essentially concerned with ‘how’ we know what we know, and how we can say that such knowledge is true. In the first half of the Twentieth Century, logical positivism (the tradition that would give rise to contemporary philosophy of science) began to promote science as the most effective means to attain true knowledge of the world and, consequently, began to dismiss non-scientific metaphysical speculations as a “meaningless quest for answers to unanswerable questions” (Dupuy 2009, 214). Although this view has become significantly less reductive, ontology evolved into a method for analysing not the ultimate constituency of reality, but the entities and relations that science discovered (Proudfoot and Lacey 2010). Ontology hence became a “metalevel discipline” (Smith 2004) concerned not with the objects of the world itself, but with the objects within the various systems of belief (theories) that frame our views of the world.

In the last decades, ontology became an important aspect of computer and information science and a fanciful means to refer to a “conceptual model” (Smith, 2004) tasked with describing objects (entities, modules, etc.) and their relationships within artificial information systems. Ontology in this sense is not concerned with the dynamics of *alternative possible worlds*. An ontology is thus a system containing descriptions, definitions, rules, taxonomies, and axioms that establish a framework for representing certain kinds of structured information within a system that may or may not interact with other systems (see Smith 2004). Outside of this specialised usage – albeit, still related to it, ontology could be seen as the method through which we categorise and make sense of the entities that surround us. In recent years, however, this translated into making sense of increasingly overwhelming amounts of *information* and the various forms in which it is generated. Thus, ontology implies not merely describing, but finding ways to organise, filtrate and discern the very things that inform and *mediate* our views of the world.

5 Ontological and epistemological changes

5.1 Computational technology is "re-ontologising" our world

Information technology (IT) is driving a revolution comparable to those initiated by Copernicus and Darwin (see Floridi 2010). This process, however, does not entail that we will all turn into cyborgs, or that virtual environments will supplant physical reality. In order to understand why and how this revolution is coming about, we could, as Floridi (2010) suggests, begin by distinguishing between 'enhancing' and 'augmenting' devices. An *enhancement* technology works in the cybernetic sense of extension and control (Dupuy 2009) (categories that include anything from spectacles to prosthetics). For its part, an *augmenting* device is one that allows users to interact with "different possible worlds" (Floridi 2010) (a microscope or even the Mars rovers would certainly fit within this category). Now, computational technology does not enhance or augment in the senses just mentioned because it allows users to *enter* an alternate environment – an "infosphere" (Floridi 2010) – in which they may interact with other human (and perhaps, eventually non-human) users.

Most of us already spend the better part of our waking hours within this environment. While our bodies remain 'tied' to a physical surrounding, a significant amount of our work, leisure and social activities take place online. But since our gadgets are now permanently within our reach (either in our pockets or around our wrists) and the 'internet of things' is gradually expanding, the once meaningful distinction between being 'online' and being 'offline' is rendered moot. By allowing us to communicate and interact with 'otherworldly' (Gualeni 2014) objects and environments (which evidently need not be as sophisticated as VR), computational technology is radically altering core tenets of our (still) modern "Newtonian" understanding of reality (Floridi 2010). One that – to paraphrase Floridi (2010) – remains populated by "dead" entities such as cars, buildings and refrigerators; but will gradually become "a-live" (artificially live) as the world becomes inhabited by *animated* gadgets controlled by invisible forces – a paradoxical reminder of pre-modern worlds.

5.2 The inadequacies of our ontological frameworks

Although our world is now filled with artefacts that sometimes contradict our modern understanding of reality, our theoretical approximations to media remain stubbornly informed by

Newtonian metaphysics. Whenever we download music or move it within or across devices we *know* we are not handling actual physical objects. What we ‘download’ and exchange are *instructions* that ‘tell’ our storage units to assume a particular magnetic configuration. Having spent most of our modern existence surrounded by physical objects, dealing with these abstract entities becomes cognitively taxing, hence, we devised visual and conceptual metaphors that allow us to handle and think about them as if they were in fact physical objects. For daily transactions, thinking about various types of digital ‘files’ and ‘folders’ is useful because it spares us the cognitive strain caused by metaphysical ambiguities. However, if what we are trying to do is understand, describe and criticise these entities, the otherwise helpful metaphors become an obstacle, because they make it seem as if digital and ‘a-live’ entities could be approached with the same ontological framework as traditional media.

Nowadays, computational technology (and technology at large) is often described through biological metaphors. Terms such as ‘environment’, ‘hybrid’ and ‘evolution’ are increasingly common across information sciences and media analyses. That media scholars turn to the natural sciences for nomenclatures is symptomatic of the absence of an adequate ontological model for digital media artefacts, and of their tacit recognition of the growing ‘a-liveness’ of technology at large¹². Computational technology clearly brings about phenomena that we do not know how to categorise; hence, we lack a *précising* definition (i.e., one that goes beyond a mere dictionary description or an awkward neologism). To a great extent, this means that we have not yet found a proper place for computational media within our conceptual framework. If these circumstances remain unchanged, our ability to describe ever more complex information (and thus media) systems will be significantly hindered.

5.3 Modelling machines

Computers are no ordinary instruments. Thanks to software’s “permanent extendibility” and “modularity” (see Manovich 2013) they have become our first multi-purpose appliances: instruments for science and engineering, but also “media machines” (Kay 2003; Manovich 2013) and entertainment centres. Computers are “intellectual tools” (Dyson 1997), which means they are not merely transforming how we do and create things, but how we *think* and understand the world, and ourselves. Like writing (our first information technology) they, are not simply means to enhance our memory, but to externalise it, to process and to communicate our thinking. Unlike writing the results of this

¹² The seemingly unavoidable arrival of AI, is bringing back old romantic metaphysical questions and anxieties (as recent calls to action by Elon Musk and Stephen Hawking show).

thinking can be objectified beyond interpretable code. Computers are *modelling* appliances that rely on information – i.e., well-formed, meaningful and truthful data (see Floridi 2004) – as their raw material. Provided that someone is capable of formulating an adequate algorithmic translation of a problem, a sufficiently powerful computer will be capable of generating a simulation through various forms of perceptible outputs. In other words, computers make abstractions tangible in a way that no other technology can. Because of them, our ideas are progressively less constrained to the limits of our ‘mind’s eye’ or by the limitations imposed by laborious analogue representations. As epistemological tools, computers both augment and permanently extend *our minds*.

By altering our epistemological boundaries (by turning the notion of ‘medium’ into a mere operational category and by encouraging transdisciplinary approaches) computational technology has forever changed the way we structure knowledge. Computers are radically transforming not only how we regard certain phenomena within a demarcated scientific field, or how we communicate and entertain ourselves and represent the world; they are changing our view on reality *itself*. They are transforming how we understand perception and experience, two fundamental aspects for all human activities, in particular for aesthetic creation. For all the ways computers are changing art and media, the most profound are not necessarily those associated with practical matters; but those resting at an intellectual level. Our theoretical difficulties do not originate solely on media theory’s long standing neglect of technology as an object of analysis, but in a deeper handicap affecting *all* human disciplines. The fact is we simply don’t *know* what entities such as software, data and information are, and to what category of ‘objects of the world’ they belong.

6 Some implications

By allowing us to build all conceivable kinds of models, computational technology has given rise to a new epistemic stance based not on theoretical models, but on *tinkering*; a kind of *permanent beta attitude*, which regards experience and artefacts as always susceptible to upgrades. Fully embraced by the third culture, this attitude and the instruments enabling it are shifting our epistemological protocols and boundaries, forcing us to rethink the way we structure and categorise our knowledge. With the computer as a primary tool, “nerd culture” is blurring the lines between craft, art and engineering and thus wreaking havoc amongst traditional disciplines by rendering their theoretical models anachronistic. The problems brought about by computational technology are not so much theoretical as they are practical. The current is

a promissory age for artists and engineers, but a complex one for theoreticians planning to keep up with their creations.

In light of such transformations, it is clear that media analyses are bound to revise both their theoretical and methodological frameworks. Given the constantly evolving nature of information technology and the permanently extendible character of the media it produces, a potential descriptive model requires the same degree of flexibility and extendibility. Nonetheless, this requires a strong ontological commitment, a core architecture over which to proceed and build future analyses; a kind of flexible ‘source code’ able to withstand extreme ‘debugging’ without falling apart. A good starting point would be to situate contemporary media within a larger critique of the phenomena responsible for producing it: information technology.

Conclusions

Our limited understanding of the metaphysical consequences brought about by information technology is one of the major impediments for developing effective descriptive models for contemporary media. This problem is further complicated by the fact that computational technology *itself* is extremely difficult to characterise, since we lack a functional category in which to place this unprecedented form of “engineering”. For media and art theorists, computational aesthetic artefacts thus present a rather difficult object of analysis. On the one hand, new approaches have to overcome the humanities’ traditional refusal to engage technology and computation beyond a superficial critique. On the other hand, art and media theory need to establish new epistemic compromises that would allow them to know, at least temporarily, what type of objects they are dealing with. Software-centric approaches go a long way towards explaining the working and history of the tools responsible for generating media. The latter problem could be better engaged by turning to philosophical approaches since they are already concerned with trying to generate appropriate models to fathom the actual nature of the artefacts transforming our world and ourselves in such profound and irreversible ways.

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Beyond Vicarious Interactions: From Theory of Mind to Theories of Systems in Ergodic Artefacts

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Keywords: Ergodic, Interaction, Simulation, Aesthetics, Procedural Design, MDA, Vicarious Interaction, Interpretation.

Procedural media allows for unprecedented modes of authorship and for the development of new aesthetic experiences. As artists and communicators, but also as readers and users of these systems, we should be aware that their aesthetic potential is not simply defined by direct interaction. Although direct interaction is one of the most perceivable components in the relationship between ergodic media or artefacts and their readers, one should not forget that the reader's interpretation and capacity to apprehend and simulate the processes developed within these artefacts is continuous, ever present and significant. In this context, this paper argues that not only ergodicity does not necessarily imply direct interaction, but also that non-interactive procedural artefacts are able to allow the development of ergodic experiences, not through direct interactions but rather through simulated interactions, by understanding procedural activities and developing mental analogues of those processes. We aim at raising this awareness, setting up the grounds for designing for what we call *virtuosic interpretation*, an activity that may be described as the ergodic experience developed by means of mental simulations.

1 Processor-based media

Digital technologies are becoming ubiquitous, replacing other media forms as very economic and reliable alternatives. They are excellent simulators of other media forms, but maybe because of this trait, they often fall short of being developed to their highest potential for the creation of new media forms. Therefore, a complete definition of digital media should not be solely based on their digital encoding but also on the fact that, being processor-based, these media forms are also essentially procedural.

Digital media may be developed in either *data-intensive* or *process-intensive* approaches (Crawford 1987), the first of these devoting most of the available resources to “moving bytes around” (Crawford 1987) in artefacts that “are based primarily on pre-recorded sound and/or image sequences, or on static texts or images that are selected or arranged during the interaction” (Kwastek 2013, 114) and mainly use their procedural capacities to select, rearrange, compose or give access to these assets. A process-intensive approach tends to produce artefacts where “sound and image data (...) will be generated in real time according to algorithms” (Kwastek 2013, 114) and where, even when data-intensive approaches are also used, the focus on procedurality is clear.

So we may emphasize procedurality in designating these media as *procedural* rather than simply *digital*, following Janet Murray’s first essential property of “digital environments” (1997, 71) and her observation that a computer “is not fundamentally a wire or a pathway but an engine”, designed to “embody complex, contingent behaviors” (1997, 72). As such, and continuing to follow Murray, we should regard authorship in these media as also being procedural, a mode of authorship where one writes “the rules by which the texts appear as well as writing the texts themselves” (1997, 152), where one creates “rules for the interactor’s involvement” and “conditions under which things will happen in response to the participant’s actions” (1997, 152). This turns the author into something of “a choreographer who supplies the rhythms, the context, and the set of steps that will be performed” (1997, 153), that creates not sets, scenes, or objects, but potential narratives to be discovered and enacted.¹ Procedural authorship therefore also underlines, and takes advantage of, the “principal value of the computer, which creates meaning through the interaction of algorithms” (Bogost 2008, 122), an ability that “fundamentally separates computers from other media” (Bogost 2008, 122) and that turns procedural media into a significantly different class of artefacts.

¹ Murray often mentions “virtual worlds”, a term that, although still useful, may be dangerous because of the way how it may ambiguously describe either the topology of the text, a procedurally simulated space or the diegetic spaces within it. More recently, Nick Montfort (2003) used the slightly less ambiguous term *simulated world* in his analysis of interactive fiction.

2 Interacting

The role of the reader² of these media is also necessarily affected. Murray describes how the “interactor, whether as navigator, protagonist, explorer or builder, makes use of this repertoire of possible steps and rhythms to improvise a particular dance among the many, many possible dances the author has enabled” (1997, 153) and how this leads readers to necessarily adopt something of a creative role within the system, although this is typically not a role equivalent to that of the author, or even not enough to qualify as co-authorship. Rather, Murray prefers to speak about *agency*, the power “over enticing and plastic materials” (1997, 153) “to take meaningful action and see the results of our decisions and choices” (1997, 112), and distinguishes it from mere activity, seeing how it “goes beyond both participation” (1997, 128), and becomes an aesthetic pleasure in itself.

Following Murray, Espen Aarseth (1997) speaks of the ergodic experience developed in artefacts where multiple user functions are possible to undertake. These are the omnipresent *interpretative* function; the *explorative* function, in which readers may make decisions regarding which spaces of the text’s topology to access; the *configurative* function, in which textual contents may be created, selected or rearranged; and the *textonic* function, when contents may be permanently added to the text. Aarseth posits that artefacts where “a cybernetic feedback loop, with information flowing from text to user (through the interpretative function) and back again (through one or more of the other functions)” may be described as *ergodic*.³ Therefore, having thus defined ergodic texts, we may conceive of other forms of ergodic media, where some of the user functions identified by Aarseth may be developed.

Allowing for interaction and agency, these media forms will be characterized by a relatively unpredictable usage, with the “string of events that occur during gameplay and the outcome of those events (...) unknown at the time the product is finished” (Hunicke et al. 2004), and the number of user functions involved, and their relative weight in the experience of the media forms may vary.⁴ Hunicke, LeBlanc and Zubek propose that artefacts such as these⁵ may be described in terms of three design stages they call *Mechanics*, *Dynamics* and *Aesthetics*, developed in consecutive levels during the artefact’s design and discovered in reverse order by their readers. The perspective of the reader is therefore opposite to that of the author in any ergodic artefact. The author deals primarily with mechanics, “at the level of data representation and algorithms” (Hunicke et al. 2004) and consequently with dynamics, the runtime behaviour of the mechanics previously developed, which will ultimately result, at the aesthetics level,

2 Among all the possible and often confusing designations – user, reader, spectator, player, interactor, etc. – we will use “reader” in this text, albeit recognizing that this also describes a particular mode of engagement with a medium or artefact.

3 *Ergodic* is a term “appropriated from physics that derives from the Greek words *ergon* and *hodos*, meaning ‘work’ and ‘path’. In ergodic literature, nontrivial effort is required to allow the reader to traverse the text.” (Aarseth 1997, 1)

4 As Markku Eskelinen notes, in literature, theatre or film the dominant user function is the interpretative, but in forms as games it is usually the configurative (Bogost 2006, 108).

5 Their MDA framework was originally developed as “a formal approach to understanding games” (Hunicke, et al. 2004). Games are undoubtedly ergodic forms and the MDA framework has been previously used by ourselves (Carvalhais 2012b) and other authors (Ribas 2012; 2014b) to study interactive and ergodic media forms.

and twice removed from the author, in “the desirable emotional responses evoked in the player, when she interacts with the game system.” (2004) Through the user functions, a reader interacts with the artefact at the aesthetics level, discovering the dynamics but normally not being able to burrow into the black box of the mechanics level.

With dynamic and continuously varying outputs that are largely unknown both to the author and the reader, we may consider the aesthetic value of interaction. Katja Kwastek notes how in data-intensive artefacts, readers may “seek to activate all the available assets” (2013, 114) in order to achieve a sense of completeness, because being used to linearity and completion in most media, we may also be “inclined to want to experience the ‘whole’ of a work” (2013, 114). In process-intensive artefacts, completeness may be found in exhausting “the underlying algorithms and the possibilities for interaction offered” (2013, 114), with the focus of the readers shifting from traditional aesthetics to an aesthetics of interaction and of performance (Ribas 2014a). This is particularly noted when readers are not engaged directly with the artefact but rather observe other readers during their interactions, a situation defined as “vicarious interaction” (Levin 2010). Of course that “sensual or cognitive comprehension can still take place in these cases” and the observer may discover “relations between action and effect, even if he is not actively involved”, not developing the same experience as an active interactor, but being “able to observe and understand interaction processes that he would not have carried out” (Kwastek 2013, 94). Furthermore, the actual performance of the interactor may also be a factor to consider aesthetically, as Siegfried Zielinski discussed (2006, 138).

3 Not interacting

Given a machine for producing text, there can be three main positions of human-machine collaboration: (1) preprocessing, in which the machine is programmed, configured, and loaded by the human; (2) coprocessing, in which the machine and the human produce text in tandem; and (3) postprocessing, in which the human selects some of the machine’s effusions and excludes others. These positions often operate together: either 1 and 2; 1 and 3; or 1, 2, and 3; or 1 by itself, although the human operator need not be the same in different positions. (Aarseth 1997, 135)

All three of Aarseth’s positions for collaboration require some direct human-computer interaction. His definition of ergodic text (or, by extension, an Aarseth-based definition of ergodic artefact) requires interaction with the human reader. Therefore, non-interactive media, even if processor-based, may be difficult to classify

as ergodic. In non-interactive artefacts – and, to an extent, in non-interactive states of otherwise interactive systems – the reader is apparently limited to the interpretative function and barred from developing any of the functions necessary to the ergodic definition. We however posit that a broader – and procedural – understanding of the nature of the interpretative function, may allow us to consider the experience of these systems as being ergodic.

4 Beyond vicarious interactions

While interacting vicariously, a reader may be able to intuit or understand the mechanical principles of a system, and to infer causal relations. This happens because by observation of the system's and the interactant's behaviours, the reader may identify regularities and patterns that lead her to expect specific reactions from both parties – from the artefact's outputs to specific actions of the interactor, and from these to particular outputs from the artefact. Although it may be questionable whether a true understanding of the artefact's mechanics is ever attained through vicarious interaction, or even through direct interaction when direct access to the code is not allowed, we may expect that if the outputs of the artefact exhibit regularities and its behaviours are somewhat determinable (Carvalhais 2010, 363), the reader may be able to develop a working model of the system that is capable of producing useful predictions regarding its behaviours or those of the pair interactant-system. This model may of course be based on false assumptions, or on the adaptation of familiar behaviours from other systems, but if it is demonstrably effective, it will also prove useful to the reader, allowing her to approach completeness in the experience of the system. As a result of vicarious interaction the reader may be able to peer through a system's aesthetics level and to develop hypotheses about dynamics and ultimately about mechanics. What then happens if interaction is removed from the experience?

When reading a dynamic and transient system with which one is not able to interact, in order to achieve a comprehension of its procedural level, and therefore of its behaviour, a reader needs to interpret beyond semantics, surpassing the traditional scope of the interpretative function. Besides the interpretation of text, images, sound and other sensorial modalities, procedural systems also allow for *procedural interpretation*. When interpreting texts, readers are “integrating details, forming and developing hypothesis, modifying, confirming, and abandoning predictions” (Douglas 1994, 175), and much of this is likewise possible to do at the procedural level.

When perceiving a system and following its outputs, a reader is not capable of directly accessing the prescriptive rules at the level of mechanics, but she is nevertheless able to make use of descriptive rules to create models that intend to explain or understand the phenomenological levels of the experience. While registering affordances on the artefact's outputs, the reader gradually identifies patterns of behaviour – starting with possible behaviours and following towards more likely or probable behaviours – and identifies relations between the perceived system and other systems or artefacts in the world.⁶ Using the data thus gathered, the reader is then able to start developing mental simulations of the processes behind the surface units found in the artefact's outputs. The reader probes the level of mechanics, constructing hypotheses that are verifiable at the level of dynamics and allow to fine-tune the mental models.

These models do not need to be based on complete sets of data, and they do not need to be rigorous to the point of generating accurate predictions of the system's behaviours.⁷ First and foremost, they need to pose testable hypothesis that can be verified with the system under observation or falsified by new findings, being then replaced by better hypothesis that ultimately contribute to a good working model of the system. This will then be gradually and continually developed by trial and error, by validation and falsification.

In the gradual understanding of a complex process from which the reader does not have but inferred clues, we may find an analogue to the process of developing theories of mind of other humans or human-like entities.⁸ A theory of mind allows one to picture “the world from another person's vantage point” and to construct “a mental model of another person's complex thoughts and intentions in order to predict and manipulate [their] behavior.” (Ramachandran 2011, loc. 2281) Based on known humans, familiar systems or mechanics, but also on other artefacts, and phenomena from the physical world, etc., humans speculate regarding mental processes, developing hypotheses that are confirmed or falsified based on the witnessed actions.

Through the developed simulations, and still from the stance of the reader, one tries to see the system from the designer's point of view, thus embracing its wholeness and fully understanding it. Interactive systems are “plastic objects” that need to be interacted with in order to be experienced and that pose the challenge of “extruding play and form, which are no longer located internal to the subject, but have to be performed” (Kirkpatrick 2011, 6) in order to be activated and to allow for an understanding of their “true structure” (Kirkpatrick 2011, 8). On the other hand, non-interactive systems, or systems in non-interactive states, do not

6 Cf. with Metzinger: “Everything we perceive is automatically portrayed as a factor in a possible interaction between ourselves and the world.” (2009, 167).

7 Being very used to interact with macroscopic and *gnarly* systems in everyday experience, readers are accustomed to a certain level of analogue variation and noise in the expected outcomes of any system. Therefore, a prediction does not need to be exact, or totally accurate, it simply needs to be roughly approximated to be evaluated as valid.

8 As V. S. Ramachandran (2011) suggests, the capacity to develop theories of mind is not exclusive to humans and not only developed towards humans but also towards entities or systems that may exhibit behaviours, emotions or “mental states” comparable to those witnessed in humans (Zunshine 2006), with “many of us even project[ing] this onto objects.” (Gazzaniga 2011, 158).

allow the user to investigate them directly through interaction, but their mental simulations developed by the user are far more plastic, versatile, and accessible. They allow for transformations, variations, and for a larger space of possibilities to be explored as a *theory of the system* is developed, a process during which one is not engaged with the artefact's diegesis or with a fiction but rather tries "to master its routines" (Kirkpatrick 2011, 8).

The process of validating the model can then be seen as leading the reader through an experience of traversal punctuated by epiphanies – when hypotheses are confirmed – and aporias – when hypotheses are disconfirmed – which may lead to the development of narrative (Aarseth 1997, 92) and even of drama⁹ in artefacts that wouldn't otherwise be experienced as narrative (Carvalhais 2012a; 2013). Furthermore, every epiphany will activate the reward centres of the reader's brain, resulting in a pleasurable experience that will drive the enjoyment of the artefact and of the experience of its simulation.

5 Ergodic contemplation

We may thus propose that non-interactive systems, or systems in non-interactive states, regardless of the impossibility to develop explorative or configurative functions by the user, may also be seen as ergodic. The mental exploration and reconfiguration of analogues – or simulations – of the systems can be seen as a de facto ergodic experience, therefore procedural works are not limited to a classic interpretation because their variability, dynamism, and procedural nature allow for a new level of virtuosic interpretation of the artefact, that while seemingly contemplative is actually very active. As with other ergodic forms, procedural artefacts require the development of a nontrivial effort from the reader in order to find not one but many paths along the traversal of the procedural space of possibilities.

In the ergodic forms studied by Aarseth the reader is "constantly reminded of inaccessible strategies and paths not taken" (1997, 3), with each decision making parts of the content more or less accessible and building up uncertainty regarding the result of one's choices and to what may or may not be missed along the traversal. In procedural artefacts the questions posed by the reader point towards how many and how diverse those paths may be, and to a discovery of how the system – unaided by a user – tends to follow them. As a result of ergodic contemplation one is then led not to build up uncertainty but rather to increase information and knowledge regarding the artefacts mechanics and to regard the possibilities to be discovered at the dynamics and aesthetics levels.

⁹ The building up of expectations regarding a system and the violation of those expectations by the system, not only contributes to the validation of the hypotheses or models, but also builds meaning from disruption, as Krome Barratt notes (1980, 301).

If in other ergodic forms the reader faces the risk of rejection (Aarseth 1997, 4), the reader of a procedural artefact has to deal with the added risk of incomprehension, that is, of being unable to build a working theory of the system that may lead to useful predictions. Naturally, with the exception of the very simplest of systems, a total understanding of the processes is not only unattainable as it is utopian, and the reader should be reconciled with that.

6 Designing for virtuosic interpretation

While developing procedural systems that intend to foster ergodic interpretation, artists and designers should be aware that much of this process of building models and testing hypotheses is developed unconsciously. A conscious procedural close reading is certainly possible but in most cases – with perhaps the exception of game forms – should not be expected. One is then faced with the question of how to communicate processes, of how to design processes that are communicable to and discoverable by the reader.

Code descriptions, procedural descriptions or even explicit code may be presented either at or with the system. These may duly inform the reader and allow for the easier elaboration of models and predictions. An example of this approach may be found in John F. Simon Jr.'s *Every Icon*, a work presented with the following text:

Given: A 32×32 Grid

Allowed: Any element of the grid to be black or white

Shown: Every Icon

(Simon 1997)

More recently, C.E.B. Reas has developed several works in his *Process* series that are presented with textual descriptions of the elements in the pieces from which dynamic compositions emerge. Elements are “machines” composed by forms (as e.g. “Circle”, “Line”) and one or more behaviours (such as “Move in a straight line”, “Constrain to surface”, “Change direction while touching another Element”, etc.). Each piece in the series is a process that “defines an environment for Elements and determines how the relationships between the Elements are visualized” and that is presented as “a short text that defines a space to explore through multiple interpretations.” (Reas 2008) As examples, we may present:

Process 18

A rectangular surface filled with instances of Element 5, each with a different size and gray value. Draw a quadrilateral connecting the endpoints of each pair of Elements that are touching. Increase the opacity

of the quadrilateral while the Elements are touching and decrease while they are not.

Process 17

A rectangular surface filled with instances of Element 5, each with a different size and gray value. Draw a transparent circle at the midpoint of each Element. Increase a circle's size and opacity while its Element is touching another Element and decrease while it is not. (Reas 2008)

10 “John Cage has used processes and has certainly accepted their results, but the processes he used were compositional ones that could not be heard when the piece was performed. The process of using the *I Ching* or imperfections in a sheet of paper to determine musical parameters can't be heard when listening to music composed that way. The compositional processes and the sounding music have no audible connection. (...) What I'm interested in is a compositional process and a sounding music that are one and the same thing.” (Reich, 1968).

11 “...defined as the susceptibility of people to read far more understanding than is warranted into strings of symbols – especially words – strung together by computers. (...) We don't confuse what electric eyes do with genuine vision. But when things get only slightly more complicated, people get far more confused – and very rapidly, too.” (Hofstadter 1995, 158).

12 “...denotes the converse situation [of the Eliza effect]. A very complex programming process is reproduced in such a simplified form that the complexity remains concealed from the recipient. Wardrip-Fruin's name for this effect refers to a 1970s story-generating computer program whose highly complex algorithms could not be discerned by the users.” (Kwastek 2013, 135).

13 A phenomenon also known as *apophenia*.

Finally, explicit code may be found in “program code poetry” (Cramer 2001), of which the works in Pall Thayer's *Microcodes* (2009-2014) series are good examples:

Sleep

31. March 2009
#!/usr/bin/perl
sleep((8*60)*60);
(Thayer 2009)

If code or procedural descriptions are not presented to the reader, processes may be designed with repetition and (some amount) of regularity in mind. As an example, algorithmic processes that largely depend on pseudo-randomness may dissimulate their structure and processes under extremes of disorder that are far off from a readable and understandable level of *effective complexity* (Galanter 2003, 8; 2008; Lloyd 2006). A balance of repetition and novelty – to which randomness can certainly contribute (Leong et al. 2008) – can ease deduction, comprehension, and the following of processes, as well as (to a certain extent) the participation of the reader in the processes.

Finally, and as Steve Reich notes in *Music as a Gradual Process* (1968), *perceptible* and gradual processes facilitate the closely detailed reading of a piece.¹⁰ Therefore, the pacing of the processes – and we must bear in mind that the timescales of modern computational devices and of human psychology and perception are very different – may also be instrumental in facilitating (or altogether allowing) ergodic interpretation.

But the processes should also be developed taking into account a series of perils or difficulties related to human interpretation of procedural systems – both natural and artificial – as e.g. being aware of psychological and perceptual illusions such as the *Eliza* effect¹¹ (Hofstadter 1995, 158) and the *Tale-Spin* effect.¹² The mental processes supporting some of these illusions should also be taken into account during development: *patternicity*,¹³ “the tendency to find meaningful patterns in both meaningful and

meaningless data” (Shermer 2011, 5) and *agenticity*, “the tendency to infuse patterns with meaning, intention, and agency” (Shermer 2011, 5).

7 Summary & Future Work

The interpretative user function should be regarded as broader and more relevant to the aesthetic experience than what one may be led to believe from its usual association with non-ergodic texts. Procedural interpretation may allow the development of rough analogues of the explorative and configurative functions, when these are not present or possible in a given context, and lead to the transfer of algorithmic processes between the artefact and the reader and to the development of a *virtuosic interpretation*.

An awareness of these processes may thus lead creators to develop artefacts that may rely on them or at least aesthetically negotiate with them, so if from traditional aesthetics we move to an aesthetics of interaction, agency and performance, we now find these also coupled with a very relevant aesthetics of process and procedurality. This paper establishes the need for this awareness, enumerating some considerations for the design of the ergodic experience of *virtuosic interpretation*, while future research aims at expanding and uncovering new considerations, developing them into a formal set of principles and guidelines.

Acknowledgements

This project was partially funded by FEDER through the Operational Competitiveness Program – COMPETE – and by national funds through the Foundation for Science and Technology – FCT – in the scope of project PEst-C/EAT/UI4057/2011 (FCOMP-OI-0124-FEDER-D22700).

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Videogame Art and the Legitimation of Videogames by the Art World

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Keywords: videogames, art, art world, legitimation

The legitimation process of a new medium as an accepted form of art is often accelerated by its adaptation by acclaimed artists. Examining the process of acceptance of popular culture, such as cinema and comic books, into the art world, we can trace historical parallels between these media and videogames. In recent years, videogames have been included in exhibitions at specialty museums or as design objects, but are conspicuously absent from traditional art museums. Artists such as Cory Arcangel, Anne-Marie Schleiner and Feng Mengbo explore the characteristics of videogames in their practices, modding and adapting the medium and its culture to their needs, creating what is often called Videogame art, which is widely exhibited in art museums but often criticised within the videogames community. This paper aims to give a perspective of Videogame art, and explore its role in the legitimation process of the videogame medium by the art world.

1 Introduction

The assimilation of a new medium into the art world has, traditionally, been a matter of contention throughout the history of art. Media such as photography, film, television, street art and comic books struggled to be recognized and respected for several years after their creation, but were eventually accepted into the network comprised of galleries, museums, biennials, festivals, auctions, critics, curators, conservators, and dealers, defined thus by art historian Robert Atkins:

The *art world* is a professional realm – or *subculture* in anthropological language – akin to those signified by the terms *Hollywood* or *Wall Street*. (...) quantitatively, it is the sum of the individuals and institutions who belong to the global network dedicated to the production, distribution, and display of art and information about it; qualitatively, it is the set of customs and habits shared by those individuals and institutions. (Atkins 2013)

What media such as film, photography, and comic books have in common is that they are forms of popular culture that have appeared fairly recently in the history of humankind, and which used to be described as having no intrinsic value beyond technological, commercial or anthropological interest. Film, television, and comic books, in particular, were accused of not only having little cultural value, but also of being vehicles for the promotion of violence and deviant behaviour, and therefore, critics affirmed, they could not be art (Jansson 2012). Similar arguments have been used towards videogames for the past four decades. The debate as to whether or not videogames can be art has become commonplace in industry events and publications, with compelling arguments from both sides.¹ But what about the medium's acceptance by the art world? Is it helped, or hindered, by the use of the videogame medium and surrounding culture by traditional artists, to create Videogame art?²

Videogame art is commonly derided by those in the videogames industry as gimmicky and implicative of a notion of inferiority to actual videogames. Matteo Bittanti quotes scholar Henry Jenkins in support of this idea:

'A few of those critics have been prepared to defend videogames as art when they are created by artists already recognized for their accomplishments in other media (...). As these works take their place in the Whitney Biennial, the curators are not so much conceding that videogames are art as they are proclaiming that "even videogames can be used to make art in the hands of real artists". Of course, the fact that highbrow artists are starting to tap game-like interfaces speaks to the impact this

¹ For opposing views, presented at the same event, compare curator Christiane Paul's presentation, "Image Games", with Tale of Tales' "Over Games," at the Art History of Games Symposium, Atlanta, Georgia, USA, February 2010.

² For the sake of consistency, this paper will use capitalization to indicate Videogame art as an artistic movement.

medium has on our visual culture. But if games are going to be thought of as art, let it be because of what Shigeru Miyamoto (Super Mario Brothers) does again and again and not because of what some pedigreed artist does once in a lark. Calling videogames art matters because it helps expand our notion of art and not because it allows curators to colonize some new space'. (Bittanti 2009)

Nevertheless, the adaptation of a relatively new medium by artists can help to accelerate that medium's acceptance by the art world. Evidence of this idea can be found by looking at the history of other popular media.

2 Other Media

As much as the contemporary art world is fascinated by the new, there is still a certain resistance to any medium that challenges previously held conventions, particularly if that medium is popular, a term usually associated with "lower" forms of culture (Tavinor 2009). However, artists themselves do not exhibit this conservatism, and are often quick to adopt new media to their purposes.

The definition of art is a complex issue, one that goes beyond the scope of this paper. The process of legitimation of a new medium as a respected art form, on the other hand, is often a practical question of academic, cultural, and political acceptance that occurs externally to the medium or object itself. With most new media, this process occurs in several overlapping stages.

First, the medium is created and developed by pioneers, who are usually inspired by previously established media and apply those media's rules and conventions to the new medium. (Alexander 2006) Early photographers, such as Julia Margaret Cameron or Gustave Le Gray, adapted motifs from painting, while early filmmakers, such as George Méliès, tended to use theatre conventions.

This is followed by the widespread acceptance and commercialization of the new medium. If it's a technology-based medium, continuous experiments are made, leading to developments which allow for more sophisticated expressions, and which make the medium more accessible, either by making it easier to work with or by lowering the technological entry point. In photography, this included the appearance of portable cameras, like Kodak, Polaroid and instant photography, and more recently, digital photography, while in cinema, the adaptation of microphones led to the appearance of talkies, among other developments:

Technology does not inherently improve a medium, though it can have this effect by allowing a wider, more expressive, vocabulary of techniques to develop. A useful comparison can be made here with cinema.

Improvements in film technology have not directly helped cinema to become a more expressive medium, but they have had a positive influence through allowing newer, more expressive, shooting techniques to emerge. (Mitchell 2003)

As a medium enters the public consciousness and becomes more pervasive, more artists are inspired by it and incorporating it into their practices. Artists have traditionally been at the forefront of new media usage and appropriation, having “always borrowed and used elements, symbols and characters both from art history and popular culture” (Jansson 2012). Comic books became a source of inspiration for artists since the 1960s. These artworks were distinguished from traditional comic books, but helped pave the way for the acceptance of comic books into cultural institutions:

The relationship between comics and modern art has a long and tangled history. (...) Some twentieth-century artists, such as Stuart Davis, Andy Warhol, and Roy Lichtenstein, utilized comic strips as the subject of their paintings. Others – including Öyvind Fahlström, Richard Hamilton, Jasper Johns, Joan Miró, and Kurt Schwitters – incorporated images or actual snippets of comic strips in their paintings and collages. (...) But in all these cases, the distinctions between the inexpensive, mass-produced comic strip and the one-of-a-kind artwork remained clear. This distinction began to blur in the 1970s with the increasing interest in non-art drawings; (...) comics began to be exhibited and collected, often in galleries or museums devoted to a particular discipline (such as the Cartoon Art Museum in San Francisco). About the same time, art galleries also began to show the original, politically pointed drawings by so-called underground comics artists such as Bill Griffith, S. Clay Wilson, and Robert Crumb. (Atkins 2013)

Likewise, many artists who were inspired by television gave rise to Video art, which is now widely regarded as one of the most important art movements of the twentieth-century. Korean-born Fluxus artist Nam June Paik is credited with having made the first pieces of Video Art (Atkins 2013), while other artists, such as Dara Birnbaum, made works inspired by television (Jansson 2012). Artists such as Lucas Samaras adopted the use of photography in their practices, while Cindy Sherman played with both the photographic medium and the conventions of cinema. Sherman is part of the “Pictures Generation”, whose members were “linked by their attraction to photography’s mechanically reproduced image, which they put to distinctly “unphotographic” purposes.” (Atkins 2013).

As the medium matures, we see the rise of *auteurs*, individuals or groups of individuals who explore the medium’s potential, by discovering what is unique to it and using that in their practices. It

often happens that this stage is associated with the rise of single, widely recognized authors, as opposed to the diffusion of authorship commonly seen in collaborative media. In the case of comic books, the appearance of the graphic novel – comics in book form, as opposed to periodicals – and authors such as Art Spiegelman and Will Eisner signalled the maturation of the medium as art. In film, directors such as Ingrid Bergman, Francis Ford Coppola, Federico Fellini and Stanley Kubrick are considered accomplished artists, their works often described as masterpieces.

Several authors have described a similar approach to this process of legitimation as applied to several media, including Janet Murray, in her text *Hamlet on the Holodeck* (1997), as described by Bryan Alexander:

Every new technology-based medium, [Murray] argues, evolves in two early stages. The first sees the porting over of forms from other media, as when early movies relied upon theatrical conventions. During the second stage creators pick up on the intrinsic elements of a new medium, and create new forms. In cinematic history, we can consider Griffith's innovation of moving the camera while filming, or Dziga Vertov's use of editing to break up filmic time and space. A similar process is visible across the history of digital media. (Alexander 2006)

Media like film, photography, and comic books were gradually accepted into the art world, and once that happened, the media's auteurs started being referred to not just as photographers, filmmakers or comic book makers – they were simply artists.

It can be argued that, when it comes to the videogame medium, several of the stages previously described have already happened. Early videogame designers and programmers contributed to the medium in its first stages, which were followed by its widespread commercialization. Technological developments led to the appearance of ever more complex gaming platforms, which developers pushed into their limits through their creations. As the popularity of videogames grew, artists started adapting them into their practices. Concurrently, in a phenomenon that started to accelerate in the latter half of the first 2000s decade, the medium saw the appearance of its auteurs, commonly referred to as indie videogame developers, with smaller or one-person teams and intentions that went beyond simple commercialization. However, the medium's maturation has not been immediately followed by its legitimation as an art form. Videogames have been largely exhibited in festivals and specialty museums, but are conspicuously absent from traditional contemporary art museums and events. On the other hand, Videogame art has become widely accepted by the art world. Starting in the 1970s, the mingling of popular and high

culture forced artistic institutions to re-evaluate and expand the concept of what could be exhibited as art, and Videogame art may help to accelerate that process when it comes to videogames. But how can we define Videogame art?

3 Videogame art as Media art

Videogame art is sometimes considered a subset of Computer art, and more commonly a subcategory of Media art. These designations can be confusing and overlapping; as Robert Atkins says in relation to Computer art, “the use of digital tools in art – and other realms of contemporary life – is so widespread that it has undermined the ability of *computer* (or *digital*) to describe something distinctive about an artwork” (Atkins 2013). Likewise, the term New Media can be described as “a blanket term that once referred exclusively to the genre of art produced by mechanical reproduction in media more recently invented than photography (...). *New media* has acquired a second, more widespread, non-art meaning, referring to all forms of digital mass media, in contrast to “old media” such as print newspapers or magazines” (Atkins 2013). It is perhaps more accurate to say that the term Videogame art originated from the twentieth-century tradition of adding the word *art* to a pre-existing medium to signal its appropriation by artists, as was the case with Video art, Mail art, Sound art, among others. Videogame art can also be described as a part of a broader concept of Playable art, which also includes art games (usually indie) and those commercial videogames that can be considered to go beyond simple entertainment.

Videogame art can be the use of videogames in a different way than the one for which they were primarily designed, or it can be the appropriation, remediation, modification or emulation of videogames, their language and surrounding culture, into an artist’s practice. The result can be anything from mods, to machinima, installations, videos and performances. However, this classification is problematic, and a source of contention between critics. There is the question of whether or not to classify as Videogame art artefacts such as paintings and sculptures that draw heavy inspiration from videogames aesthetics or culture. Matteo Bitanti includes those artefacts in his definition:

Game art is any art in which digital games played a significant role in the creation, production, and/or display of the artwork (The reason why I’m mentioning this is because my own definition of Game Art is broader than the ones formulated by many other critics, as it encompasses traditional artefacts such as painting, sculpture, and photography, and not only digital works.) (...) The resulting artwork can exist as a game,

painting, photograph, sound, animation, video, performance, or gallery installation. (Bittanti 2009)

However, Bittanti singles out art games, a term often used to describe games made by indie authors with a specific artistic intent, as being left out of the discussion: “Although art games may be considered an expression of Game art, we decided – for a variety of reasons – not to include them (...)” (Bittanti 2000). Traditionally, art games have not been included in the category of Videogame art. However, games that are made from scratch by artists, such as *The Night Journey* (2007), an experimental videogame made by Bill Viola, a celebrated and widely exhibited video artist, raise further questions. On the surface, *The Night Journey* is similar to many so-called art games, so does it need a different classification because it was made by a traditional artist, as opposed to being made by a game developer?

This question can be illustrated by looking at the example of the Museum of Modern Art (MoMA) in New York. The MoMA is notorious for being one of the first museums in the world to include videogames, both commercial – such as *Tetris* (1984), *The Sims* (2000) and *EVE Online* (2003) – and indie – *fIOW* (2006) and *Passage* (2008) – in its collection (Heddaya 2013). However, those videogames are in the collection of the Department of Architecture and Design. In contrast, Chinese artist Feng Mengbo’s work *Long March: Restart* (2008), described by Mathias Jansson as “a large-scale interactive video-game installation” (Jansson 2012), is listed in the Department of Media and Performance Art, classified as an installation.³ What makes this object art, and the other ones design or applied art? A subtle difference can be spotted in the medium’s description, with the traditional videogames described as “video game software” (and therefore, one could suppose, standard), as opposed to *Long March: Restart*, which is described as “video game (color, sound), custom computer software, wireless game controller”.⁴

Similarly, another source of contention is the work of cross-disciplinary artist Toshio Iwai, who beyond working with installations, music (he created *Tenori-on*, a handheld digital musical instrument that became a part of MoMA’s Design collection in 2009), and television, has also created commercial videogames, such as *Electroplankton* (2005) for the Nintendo DS. The fluidity of the categories can be understood from Grethe Mitchell and Andy Clarke’s view when discussing Videogame art:

We wish to exclude from our discussion the work of artists such as Toshio Iwai, whose interest is in the creation of wholly original videogames for use within a gallery setting. (...) We are not excluding all gallery-based

³ See Feng Mengbo’s *Long March: Restart* (2008) in MoMA’s collection: http://www.moma.org/collection/browse_results.php?object_id=122872, compared to, for example, Rand and Robyn Miller’s *Myst* (1993): http://www.moma.org/collection/browse_results.php?object_id=164918.

⁴ The exception to which is Jason Rohrer’s *Passage* (2007), described as “SDL, GNU Compiler Collection, GNU Emacs, mtPaint, CVS, and MinGW-MSYS software”: http://www.moma.org/collection/browse_results.php?object_id=145533.

work from our discussion, but wish to make a distinction between the work of artists such as Iwai, which is typically described using terms such as “audio-visual installation” rather than videogame, and that of groups such as Blast Theory, where the relationship with the world of games and videogames is explicit, acknowledged, and intrinsic to the work. (Mitchell 2003)

The authors go on to propose grouping videogame artworks under the categories of remixing, reference, reworking, and reaction (Mitchell 2003). This categorization, while useful, is insufficient for the purposes of this paper, which will follow an approach closer to Matteo Bittanti and Domenico Quaranta’s. As such, Videogame art is art created by traditional artists that appropriates the technology, language, content and culture of videogames to produce artefacts such as machinima, patches, mods, paintings, photographs, sculptures, performances, video, animation, games, interventions and installations, as well as works that challenge easy categorization.

The following section is a short selection of artists working within Videogame art, in order to highlight diverse developments in the movement. Due to space constraints, this selection is meant to be illustrative, not exhaustive, and is necessarily missing important artists in the field.⁵

4 Videogame Artists

Chinese artist Feng Mengbo was among the first to appropriate videogame aesthetics into his practice. Mengbo’s work is described as belonging to Political Pop, a term coined by critic Li Xianting in 1992 to describe an artistic movement “derived from Western Pop art’s visually arresting depictions of everyday subjects in styles borrowed from comics and advertising” (Atkins 2013). Mengbo first linked political sensibilities with popular entertainment in *The Video Endgame Series* (1993), “a series of acrylic-on-canvas paintings in which he mixed images from the Cultural Revolution (1966-1976) with his childhood memories of playing 8-bit video games” (Jansson 2012). In 1994, he created *Game Over: Long March*, a series of 42 paintings that closely resemble screenshots from early videogames. In 1997, Mengbo created the interactive CD-Rom *Taking Mount Doom by Strategy*, “an interactive gaming platform that blends the idealized Cultural Revolution-era opera *Taking Tiger Mountain by Strategy* and the violent Western video game *Doom*” (Atkins 2013). He modified *Quake* (1996) to create several works such as the machinima-based *Q3* (1999), and the playable mods *Q4U* (2002) and *Ah_Q* (2004), from which he also created several photographs and paintings derived from screen

⁵ For example, Harun Farocki, Jon Haddock, Tabor Robak, and the art collective JODI, to name only a few.

captures (Krischer 2009). More recently, he created *Long March: Restart* (2009), which is played on two large, opposing screens, forcing the player to turn around and face another screen to advance through the game's levels. Writer Carolina A. Miranda describes the game:

Visually it is a paean to classic games of the 1980s such as *Super Mario Bros.* and *Street Fighter*, but its narrative is largely focused on 20th-century Chinese history, specifically the Long March, the Communist Army's gruelling 6,000-mile retreat from the more powerful Nationalist Army in the mid-1930s. In Mengbo's game, the player guides an avatar, a blue-suited member of Mao Zedong's Red Guard, through the various stages of the Long March – all while pelting an array of intergalactic enemy villains with cans of Coca-Cola. (Miranda 2011)

Feng Mengbo exhibited *The Video Endgame Series* (1993) at the 45th Venice Biennale. Since then, his videogame-based works have been exhibited extensively all over the world, from the Dia Center for the Arts in New York, to the Ullens Center for Contemporary Art in Beijing. In 2002, *Q4U* (2002) was included in Documenta 11. Following the acquisition of *Long March: Restart* (2009) to MoMA's collection, the piece was exhibited at MoMA PS1 (Jansson 2012).

Greek painter and multimedia artist Miltos Manetas, famous for creating Internet artworks such as *JacksonPollock.org* (2003) and *WhitneyBiennial.com* (2002), was, together with Mengbo, among the first to use videogames iconography in his work. His series *Videos after Video Game* (1996-2006) – which included *Flames* (1997), a video in which Tomb Raider's Lara Croft is killed by poisonous arrows, and *Super Mario Sleeping* (1997) – is considered the first example of machinima (Bittanti 2010). He has created several paintings based on videogames culture, and was among the first artists to depict the act of gaming:

Painted in 1997, the piece *Christine with Playstation* evokes another fleeting moment of style. Angled from above, the painting surveys a domestic scene, the eponymous girl or woman kneels on the floor in front of the television, leaning forward and resting her elbows on a large floor cushion, and holding what is clearly a game controller. (Apperley 2013)

Among the first artists to create mods based in videogames was Orhan Kipcak, who in 1995 created *ArsDoom* with Reini Urban:

Using the *Doom II* engine and Autodesk's AutoCAD software, Kipcak and Urban created a virtual copy of the Brucknerhaus' [the venue for Ars Electronica Festival in Linz] exhibition hall and invited artists to create or submit virtual artworks that could be displayed in the new map.

Armed with a shooting cross, a chainsaw or a brush the player could kill the artists and destroy all the artworks on display. (Jansson 2009)

A similar approach was used by Swedish artists Tobias Bernstrup and Pelle Torsson, who in 1996 started modifying existing videogames such as *Duke Nukem 3D* (1996) and *Half-Life* (1998) based on reconstructions of art museums such as the Arken Museum of Modern Art in Copenhagen and Moderna Museet in Stockholm. The result, *Museum Meltdown* (1996-1999) allows players to “run around the museum, shoot monsters, and destroy art” (Jansson 2012).

Another example of a videogame art mod based on *Half-Life* is *Adam Killer* (1999) by Berlin-based artist Brody Condon. In this piece, the player is confronted with multiple replicas of the white-clad figure of “Adam”, standing passively in a room; the player can either do nothing or kill the Adams. Condon exploited a glitch in the game in order to create trailing textures and effects (Gavin 2014). *Suicide Solution* (2004) is a DVD documentation of characters committing suicide in over fifty commercial shooter games.⁶ Condon has also experimented with intervention in multiplayer online games with *Gunship Ready* (2001):

Designed as a modification of the online game *Tribes*, this work provides a flying gunship within the world of the game. The players are beckoned by the artist to climb onto this vehicle, but when they do, they find that they are taken on a tour around and eventually away from the battleground. They have been kidnapped (by the artist), rather than, as they thought, being taken to more exciting battle. Having been abducted, they are presented with the situation where they must kill themselves (in the game) in order to re-enter the action. (Mitchell 2003)

From the 2000s, artists continued staging performances and interventions within videogame spaces. During the 2004 Republican National Convention in New York, in a work titled *Operation Urban Terrain (OUT): A Live Action Wireless Gaming Urban Intervention*, Anne-Marie Schleiner “armed herself with a mobile Internet connection, a bicycle, a battery-powered video projector, a team of players and technicians, and a laptop” (Flanagan 2009), entered the videogame *America’s Army* (2002) and discussed anti-war ideas with the players, projecting the live game session into the urban space. *Velvet-Strike* (2003) is a downloadable collection of spray paints for the walls of *Counter-Strike* (2000) by Schleiner, Brody Condon, and Joan Leandre:

A player, having installed Velvet-Strike, enters a usual online shooter game and is able to spray clearly seeable messages to other players on her surroundings. The sprays one can download from the project’s web site

⁶ See Brody Condon’s website: <http://tmpspace.com/>

range from textual anti-war messages (“If god says to you to kill people / kill god”) over rendered posters of soldiers in intimate poses to graffitiquesque depictions of teddy bears shooting “love bubbles”. (Pichlmair 2006)

Joseph DeLappe’s *Dead-in-iraq* (2006-2011) is another intervention into *America’s Army* (2002), the U.S. army recruiting game. Starting in 2006, DeLappe entered the game and proceeded to type (saying to the other players) the names of American soldiers who died in the Iraq war. Inevitably, the other players killed him; he re-incarnated and continued to type. He did so until December 2011, “the announced withdrawal date of the last U.S. troops in Iraq. Delappe had entered a total of 4484 names in the game” (Jansson 2012).

Artistic interventions within game spaces can be considered performance artworks. This performativity was explored by artists such as Gazira Babeli, a performance artist who exists in the virtual world of *Second Life* (2003). Within the game, she manipulates the virtual world in order to create prints, performances and movies, such as *Gaz of the Desert* (2007), which can then be exhibited in the physical world.

In 2007, Eva and Franco Mattes⁷ began to re-enact famous performance pieces from the history of art within *Second Life*. One of their chosen performances was Vito Acconci’s *Seedbed* (1972) and they also conducted other performances by Chris Burden, Marina Abramovic, and Gilbert & George.

Several artists have created artworks that allow game spaces to intervene in the physical world. Antoinette J. Citizen created *Landscape* (2008), an installation that transformed a gallery room into a *Super Mario* level, complete with interactive boxes with questions marks and bricks that produced sounds.⁸ Berlin-based artist Aram Bartholl has created several works which allow videogames to invade the real world, such as *WoW* (2006-2009), an intervention in which participants construct their own names out of green cardboard and walk around with them hovering over their heads, as if they were avatars in *World of Warcraft* (2004). He has also brought to life a game level in *Dust – Winter Prison* (2013), a large-scale installation at an old prison yard in Quebec, inspired by the map *Dust* from *Counter-Strike* (2000).⁹

Several artists have experimented with the physicality of videogames in other ways. The artist duo //////////fur//// (Voker Morawe and Tilman Reiff) created *PainStation* (2001), a two-person gaming console based on the game *Pong* (1972) which punishes losing players with physical pain on their hands, in the form of heat, electric shots or a whiplash (Jansson 2012). The physical body of the player is also implicated in multimedia artist Eddo Stern’s work. His project *Darkgame 2* (2007/2008) is a sensory deprivation

⁷ Also known as 0100101110101101.ORG.

⁸ See the work on Antoinette J. Citizen’s website: <http://antoinettejcitizen.com/installation/landscape/>

⁹ See Aram Bartholl’s website: <http://datenform.de/>

videogame that dynamically separates the player from the avatar on screen through the use of a head device: as the player loses his or her physical sensory abilities, the character becomes stronger in the game. Together with Mark Allen, Stern did the performance *Tekken Torture Tournament* (2001), in which “the participating players were equipped with special bracelets. When the player was hit by the other player on the screen, he got an electric shock in the arm. (...) The bracelet was a form of interface that could connect the virtual pain with the player’s physical body and transfer the virtual violence into the real world” (Jansson 2012). Similarly, Riley Hammond’s installation *What it is without the hand that wields it* (2008) attempts to turn the virtual experience of videogames into a physical one:

The installation was an electronic sculpture attached to a server where people played Counterstrike. The sculpture consisted of a number of blood bags with tubing that was connected to nozzles that were opened when one of the players on the server was shot. The virtual killing and violence ran, so to speak, over to reality, the virtual blood in the game was solidified on the gallery floor. (Jansson 2012)

Perhaps the best-known practitioner of Videogame Art is Cory Arcangel, a multimedia, post-conceptual artist who “collects outmoded computer games, decrepit turntables and similar castoffs (...). Through a bit of ingenious meddling, he reboots this detritus to produce witty, and touchingly homemade, video and art installations” (Spears 2011). His earliest piece of Videogame Art is *Super Mario Clouds* (2008), a NES *Super Mario Bros* (1985) cartridge that he hacked to erase everything except for the clouds, effectively rendering the game unplayable. This was followed by other pieces based on modified code, such as *I Shot Andy Warhol* (2002), a *Hogan’s Alley* (1984) mod in which the gangsters have been replaced by artist Andy Warhol, while the innocents have been replaced by the Pope, Flavor Flav and Col Sanders, and *F1 Racer Mod (aka Japanese Driving Game)* (2004), a mod of the Famicom game *F-1 Race* (1984), from which he erased the cars and left only the road and the scrolling landscape. The 15-minute movie *Super Mario Movie* (2005) was produced in collaboration with artist collective Paper Rad:

(...) our protagonist is thrown into a world neither he nor we can comprehend. The rules of the game universe are turned upside down, colors shift, Mario floats on air. The game’s text becomes nonsense and the screen is at times overtaken by vaguely familiar symbols and abstract patterns. Through this all, Mario wanders. (Chayka 2011)

Arcangel has also produced *Various Self Playing Bowling Games* (2011), a series of large-scale projections of bowling games from the late 1970s to the 2000s, to which he added several modded game controllers so that the characters on screen would throw only straight gutter balls. Similarly, *Self Playing Nintendo 64 NBA Courtside 2* (2011) is a mod in which the characters are programmed to miss their shots continually via a modded controller.

Cory Arcangel's work has been exhibited both in solo and group exhibitions in places such as the Whitney Museum of American Art, New York, the Barbican Centre, London, and at the Warhol Museum, Pittsburgh, among others.

From this selection of artists working with Videogame Art, it is possible to identify a few trends. The first artworks to appear were mainly traditional artefacts, such as paintings, photographs and videos, which either referenced videogames or were directly appropriated from the games, through screenshots and machinima. Art mods have tended to favour older games, perhaps because they are easier to hack and modify than more recent ones (the same goes for the hardware). As videogames became more complex, artists started staging performative interventions within the game space, often interacting with other, regular players. And as the medium matured, artists started to explore the potential physicality of videogames, effectively blurring the boundaries between virtual and physical space.

Concurrent to these developments, the mid-2000s saw the rise of indie videogame developers and the widespread appearance of art games. Some artists, such as the afore-mentioned Bill Viola, collaborated with videogame developers in order to bring their vision into reality. We can perhaps detect a subtle convergence between Videogame art and more traditional videogames, leading us to speculate that, as the technologies that allowed the creation of videogames became more sophisticated and accessible, and as artists became more literate in the medium, they no longer felt the need to create mods, and instead started to enter the world of designing and developing games, effectively becoming the medium's auteurs.

5 Videogames and the Art World

In the last fifteen years or so, Videogame art has been exhibited in art museums alongside more traditional artefacts. Some examples of such exhibitions, beyond those that were already mentioned, are "Game Show" (2002) at Mass MoCA, Massachusetts, "re:Play" (2003) at the Institute for Contemporary Art in Cape Town, "Killer Instinct" (2003) at the New Museum in New York, "Bang the Machine: Computer Gaming Art and Artifacts" (2004)

at the Yerba Buena Center for the Arts, San Francisco, and “Space Invaders” (2011) produced collaboratively by FACT (Foundation for Art and Creative Technology, Liverpool, the Nikolaj Copenhagen Contemporary Art Centre, and the Netherlands Media Art Institute in Amsterdam. Art games are also often included in these exhibitions.

Christiane Paul, Adjunct Curator of New Media Arts at the Whitney Museum of American Art, has been at the forefront of exhibiting both Videogame art and art games, both at the museum, the biennial and *artport*, the Whitney Museum’s website dedicated to New media art. Works by Cory Arcangel and the *Velvet-Strike* mod have been included at the 2004 Whitney Biennial. Another institution that recognized early on the importance of Videogame art was the Laboral Centro de Arte y Créacion Industrial in Gijon, Spain, with exhibitions such as “Gameworld”, “Playware” (2008) and “Homo Ludens Ludens”.

Traditional videogames, on the other hand, are mostly exhibited in museums as design objects, with most exhibitions that defend videogames as art taking place in specialty galleries, museums and events dedicated to design, art and technology. This is not necessarily negative: many of these museums are exploring the cutting edge of art, and actively pushing the boundaries of what is considered art and what is not. However, it is extremely rare to see them exhibited in contemporary art museums, alongside sculptures, paintings, performances and installations. Mostly, these museums use them as support materials by their educational department.

Resistance to the idea of videogames as art stems in large part from the fact that they can be considered popular entertainment, and therefore too simplistic to be considered art. Traditionally, in Western culture, certain media – painting, sculpture, or literature – have been considered inherently better and more dignified than others – notably, television, comic books, and games. The Pop art movement questioned the boundaries between high and low culture, and the distinction has become increasingly blurry, with more and more areas of human production becoming recognized as artistic (Atkins 2013). Ultimately, once a medium has matured, the process of legitimization is driven by forces external to the objects produced. Certain videogames exhibit conditions, like rules, objectives, and competition, which seem to be outside a traditional conception of the arts; however, they also exhibit many characteristics that approximate them to other artistic media, such as “aesthetic pleasure, stylistic richness, emotional saturation, imaginative involvement, criticism, virtuosity, representation, and even special focus and institutional aspects” (Perron 2009).

Beyond appropriation by traditional artists and the subsequent assimilation by the art world, a medium's acceptance is also influenced by the appearance of criticism and academic studies. With the proliferation of game studies and a more established tradition of serious criticism of videogames, there is still a need for extensive work when it comes to exhibiting, collecting, and contextually framing videogames, in order for them to achieve the status of an art form.

6 Conclusion

Beyond the highly debated question of whether videogames can be art or not, there is the question of Videogame art and its acceptance into art museums, and whether it helps or hinders the medium of videogames. Those who defend videogames as art often criticize the inferiority that the designation Videogame art (and, for that matter, art games) implies. The purpose of this paper has been to argue that, as it happened with the legitimization of other media, the movement of artists adapting videogames into their work helps to accelerate the process of acceptance of videogames as artistic objects in their own right. When introduced into galleries, museums, and biennials, audiences are exposed to videogames in a different context than the one they are used to, and artists, curators, and critics are encouraged to think about the medium critically.

Even if some game developers disagree with their work being considered art, there are many others who consciously affirm their intention of creating art. While the legitimization of a medium as art is not necessary for the development of that medium, it can have considerable value: if something is considered art, then it is more easily protected by creativity and free speech laws (Jenkins 2005). It can also have an impact on how the public sees videogames.¹⁰ In addition, from a museological point of view, videogames put into question traditional modes of exhibition and archival. Videogames' technological demands, the fact that they transform the audience from viewers to players, and the issue of placing them in exhibition spaces largely unprepared to receive them, are among the specific questions that cultural institutions and professionals must acknowledge. Moreover, archiving videogames implies more than just preserving the software: historians need to keep in mind, among other things, the hardware used and the context in which videogames appeared, as well as support materials. Several organizations and art historians have already started to address the problems of game preservation, and the acceptance of videogames can only add to this process.

¹⁰ The importance of the public's opinion on the artistic status of a given medium can be illustrated by looking at the history of comic books and their censorship.

Videogames already have the potential to become one of the most important art forms of this century. Their appropriation by artists can help to explore, question and advance videogames as a medium, which is perhaps a more worthy goal than striving for their legitimation as art by the fickle art world. But their potential influence in promoting videogame's acceptance into art institutions is important to acknowledge, especially for those who believe and fight for that artistic status, in order to further the discussion and effect change.

Acknowledgements.

The core argument in this essay was initially developed as a talk proposal by the same name, and accepted for presentation at the Indiecade East 2015 conference, on February 13–15, at the Museum of Moving Image in New York City.

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Creative Surrogates: Supporting Decision-Making in Ubiquitous Musical Activities

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Keywords: ubiquitous music, creativity-centered design, graphic-procedural tagging, creative surrogates.

We present results of two studies that address creative decision-making through the usage of local resources. Adopting an opportunistic design approach (Buxton 2007; Botero et al. 2010; Visser 1994), both studies use off-the-shelf infrastructure to identify support strategies that deserve further implementation efforts. Both studies yielded complete creative products, consisting of a mixed-media performance artwork and a multimodal installation. We discuss the procedures employed to assist the decision-making processes with an eye on the development of new creativity support metaphors. The examples serve to frame the discussion on human-computer interaction and musical creativity in the context of ubiquitous music making.

1 Introduction

This paper deals with the convergence of interaction design techniques and artistic practices. Analyzing two design projects – involving multiple iterations – the impact of creative practices on interaction design methods are discussed. On the one hand, the development of technological support for creative practices opens up new opportunities for artistic application. On the other hand, the concepts unveiled through the study of creativity expand the potential for participation in artistic practices. One of the theoretical and methodological perspectives exploring this convergence is ubiquitous music research (Keller et al. 2014a).

Recent advances on creative practices in information technology (Mitchell et al. 2003; Shneiderman 2007; Shneiderman et al. 2005) indicate the need to change the focus from technological product development to support for meaningful experiences (Rogers 2014). Creative computing highlights the non-utilitarian aspects of technology inserted in everyday life (see for example, Bødker 2006; Harrison et al. 2007). More recently, the aesthetics interaction design perspective broadens the range of the application of artistic endeavors to assess the results of human-computer experiences (Keller et al. 2014b; Löwgren 2009).

In this paper, we discuss exploratory strategies in creativity-centered design (Lima et al. 2012) as a way to encompass research methods for the study of creative procedures that yield relevant and original products. We analyze two artistic applications of the graphic-procedural metaphor, focusing on its limitations and its applicability within the realm of artistic creativity. The results show good potential for enhancing audience participation in music making and for expanding the available spaces for creative action beyond collocated activity. The graphic-procedural metaphor allows for the use of visual elements to organize temporal parameters asynchronously. This metaphor is based on close relationships among local material resources and creative decisions, mediated by the action of the participants. This mediation mechanism puts the focus on the active participation of stakeholders in the creative act, emphasizing the human side of creativity support.

2 Ubiquitous Music and Creative Design

A key aspect of the creative process is the choice or development of technological support. This task involves finding out how material, cognitive and social factors influence the strategies applied in decision-making. Our overall proposal is to expand the study of creativity to the context of everyday actions. More specifically, we

want to insert music creation in settings that were not originally designed for music making. A first step has already been taken by experimental studies in ubiquitous music. Ubiquitous music - or *ubimus* (Keller et al 2014a) - emerges as a theoretical and methodological alternative to the approaches attached to the European instrumental musical tradition of the nineteenth century (Tanaka 2009; Wessel and Wright 2002). Ubiquitous musical activities generally use distributed resources and involve multiple stakeholders with various levels of expertise. While ubiquitous music requires expanding the access to creative activity by laypeople, the acoustic-instrumental paradigm demands a strict separation between novices and musicians-performers.

Most research in musical interaction has focused on the validation of instrumental music tools (Tsandilas et al. 2009) or on simulations and extensions of musical instruments (International Conference for New Instruments for Musical Expression – NIME). By grounding the design choices on instrumental music molds, the researcher reduces the participant's role to a consumer of ready-made procedures predefining the aesthetic perspective to be adopted. Thus, the creative choices are established by the research design, rather than by the subjects-participants. Hence, the results reflect the methodological choices of the experimental design restricting the participation of the creator to a predefined creative path. This caveat has been term *early domain restriction* (Keller et al. 2011b).

The procedures that have emerged for supporting ubiquitous musical activities encompass four inter-related stages: defining strategies, planning, prototyping and assessment (Pimenta et al. 2014). Given the iterative and participatory nature of our design practice, these four stages are not necessarily successive and each stage may be repeated several times during the development cycle. Our practice suggests three emergent methodological trends that may be used as general guidelines to define design strategies: (a) avoid early domain restriction; (b) support rapid prototyping; and (c) foster social interaction. After the initial choice of design strategies, planning activities may be pursued in the form of exploratory studies. The objective of this design phase is to obtain a set of requirements and to gather initial feedback on user expectations. Once the minimal requirements and the overall objectives of the project have been set, simple prototypes can be built to allow for more detailed on-site observations. Prototypes do not need to be complete software solutions. This stage's objective is to gather useful information on specific aspects of the musical experience. Thus, sonic outcomes can be handled by simplified signal-processing tools (Lazzarini et al. 2012; 2014b) or by Wizard of Oz simulations (Gould et al. 1983). Design issues of the

adopted interaction approach can be studied by using software mash-ups, verbal scores, aural scores, graphic scores, storyboards, videos and animations. The focus is fast turnover, not refined implementations.

To be able to orchestrate these activities is a tricky business. So no ready-made recipes are available yet. Furthermore, to guide the choice of technologies and interactivities that support the on-going creative activity some sort of assessment is necessary and this should be as closely tied to the activity as conditions permit. Both objective data – related to the subjects' profile, activity variables, environmental variables and technological infrastructure – and subjective data – the subjects' feedback on various aspects of the experience – should be gathered. Through comparisons among various conditions, it is possible to evaluate the impact of the material and the social resources on the participants' performance. These results feed the previous design phases, pointing to updated strategies and prototype refinements.

2.1 Creativity support metaphors

Creativity support metaphors are at the contact point between musical interaction metaphors (Pimenta et al. 2012) and the proposals laid out in interaction aesthetics applied to creativity (Keller et al. 2014b). The focus is the sustainable support of creative activity, covering on the one hand the activity results - the creative products and the generation of resources - and on the other hand, dealing with the procedures required to achieve creative outputs - the creative or design processes. This latter aspect differentiates the metaphors for creative action from musical interaction metaphors. While musical interaction metaphors provide the necessary support for novices and musicians to be able to achieve musical results, metaphors for creative action target the increase of the participants' creative potentials. This creative potential can impact the intended and the unintended products of the activity. Hence, the main goal of the support is not the creative product itself, but the ability of the agents to take advantage of the resources available at the site of the activity.

Classic examples of support metaphors for musical creative activities are the proportional notation systems. In this case we are talking about *proto-metaphors*, since they don't reach the level of flexibility necessary to enable activities in everyday contexts. In proportional notation, the visual representation is directly correlated to the sound parameters (Cope 1974; Keller and Budasz 2010). For instance, a point represents a sound event with a short duration. A long line indicates a sustained sonic event. One of the limitations of proportional notation is the distance between the

those observed in multiple-scale self-similar systems (e.g., chaotic and fractal systems) (Malt 1996).

The selection strategy applied in *Tocaflor* prioritized visual objects that could provide an intuitive dimensioning within a close range to the size of the human body. Picture 16, chosen as a basis for the composition, is simple yet it has enough visual elements that can be used as musical data (see picture 16 in Figure 1). The arrangement of flowers on the horizontal axis suggests an approximate mapping to duration, through matching the spatial position of the flowers to the temporal position of the event (Melo and Keller 2013). The vertical axis can be interpreted as pitch. Colors can be mapped to timbre or sound source. Other sound parameters, such as intensity, can be related to thickness or size of the visual cue. To maintain the material accessible to performers, we decided to adopt pitch as the only parameter displayed on the vertical axis, scaling the frequency values from lower to higher, from the bottom to the top of the figure.

After listening to the local sound material, it was decided that it was sufficiently interesting on its own, so other than simple editing, no sound processing was applied. From the database of collected sound samples, materials recorded during the morning session were chosen. The selected recording has a complex texture featuring bird singing and other biophonic events. Most sounds are concentrated on a frequency band higher than the pitch range of wind instruments. Therefore, the soundtrack works as an independent layer that can be used to inform the way the visual events can be interpreted. This material served as a basis to deal with the visual parameters, highlighting the relationships of complementarity between local sound materials and local visual resources.

Having established the visual and audio materials to be employed during the compositional process, we created a reference system to generate musical data from the collected visual data. Firstly, we eliminated the background colors, yielding a neutral gray-scale base. Subsequently, a selective filter was applied to restore color to the red flowers. A similar procedure was applied to recover the yellow flowers. The resulting pattern featured lines and dots in two colors (figure 2). In order to interpret the graphics as instrumental performance parameters, we applied a reference grid on top of the bi-colored patterns. As a compositional choice, all events were restricted to the instrumental range of the clarinet. Given the continuous distribution of visual elements on the vertical axis, the position of the elements could simply be interpreted as micro tonal changes. Thus we avoided the use of complex symbols to indicate subtle inflexions of tone. Nevertheless, in order to introduce time as a control parameter, it was necessary

to implement a format that supported the projection of time-based frames. Considering that most devices can handle multimedia material, we decided to adopt video as the delivery format. This choice extends Nance's (2007) aural scores to the realm of

Fig. 2 Reference system and tracker in *Tocaflor*.



the audiovisual.

First, we cropped the image as a series of rectangles. Each rectangle corresponds to a frame within the visual sequence. To provide a cue of the passage of time, we added a color-changing tracker on top of the reference lines. Duration was mapped as a 1:1 proportion between position and execution. Hence, the positions of the events are shown exactly at the time they have to be performed, avoiding ambiguities in the relation notation-performance. The audiovisual score was rendered as a standard video file and, to allow for distributed performances, it was shared on YouTube (Melo and Keller 2013).

Creative results

The graphic-procedural metaphor supports the use of visual elements to organize temporal parameters synchronously. As a case study, we described the creation and performance of the multimedia work *Tocaflor* for two clarinets and stereo electroacoustic soundtrack. The resulting creative surrogate is a 5:20-minute audiovisual score. Location-specific visual material is anchored (Keller et al. 2010) through a time-based bi-dimensional reference system. The visual anchors are used as performance instructions within the audiovisual score. The piece was presented in November 2013 at the Amazon International Symposium on Music (Melo and Keller 2013).

The application of the graphic-procedural metaphor was described in the previous section as an instance of a general strategy to support collocated, asynchronous creative decision-making. The use of local resources indicated a viable strategy for opportunistic design (Hartmann et al. 2008; Keller et al. 2013; Visser 1994). Creative surrogates - in the form of visual data - were used to assist the compositional procedures. Through the application of a time-based reference system, by means of an

audiovisual tracker, visual features were converted into instructions that yielded sonic events.

Fig. 3 Creativity support metaphors for synchronous decision-making: audiovisual trackers.

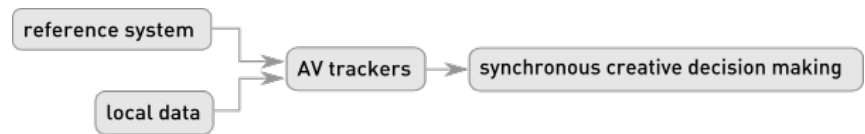


Figure 3 summarizes the flow of information applied during the *Tocaflor* study. The first stage involved gathering visual data on site. This data was externalized as creative surrogates by means of graphic transformations. The adopted reference system provided a mechanism to map visual features of the materials to sonic events. An AV tracker was used to guide the musicians' interpretation of the visual elements, providing support for the collocated, synchronous musical activity.

2.3 Study 2: Creative surrogates in Palafito 1.0

A ten-month design study targeting the observation of creative artistic practice by a video-artist, a sculptor and a composer, yielded the multimedia installation *Palafito/Palafita/Home-on-stilts 1.0* (Capasso, Keller and Tinajero 2012). Asynchronous, ubiquitous group activities were carried out by the three subjects through lightweight, off-the-shelf infrastructure. Data was extracted from a virtual forum and a file repository (see next section, procedures, to see the nature of the data collected). The analysis of the creative exchange indicated cycles of activity alternating between reflection, exploratory action and product-oriented action. Technological support was incorporated through cycles of demand-trial-assessment, embracing a parsimonious approach to the adoption of new information technology objects. Through the adoption of an opportunistic design strategy (Keller et al. 2013; Visser 1994), priority was given to repurposing of existing resources as opposed to development from scratch. Creative results included 19:30 minutes of sonic material and video footage, and three 5x8x3-meter raw-wood sculptures.

Settings and materials

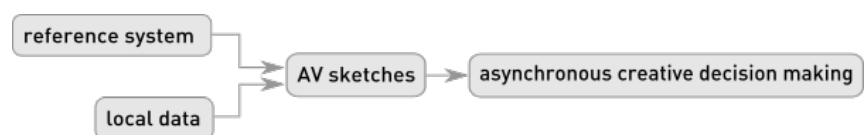
This design study avoided the introduction of disruptive environmental factors by adopting the artists' usual working settings. Audiovisual source materials were gathered by the authors through an ecompositional journey that encompassed several locations in the Ecuadorean and Peruvian Amazon tropical forest (Keller 2004). These raw materials served as anchors (Keller et

al. 2010), for the elaboration of the sculptural, visual, and sonic elements utilized in the piece. The experience of the journey provided the social grounding for the conceptual relationships later developed in the multimodal installation (Keller et al. 2014c).

Procedures

During a ten-month period, the three subjects' creative activities were monitored using two tools: a virtual forum and a file-exchange repository. The creative exchanges were classified into four distinct types of activity (Keller et al. 2014c): argumentation (a form of dialogic activity involving verbal exchanges), reflective activity (when no material resources were exchanged), epistemic activity (exploratory actions targeting increased knowledge to inform decision-making) and enactive activities (actions that impact material resources and products). Although a detailed description of the classifications made and the overall exchange processes are beyond the scope of this present paper we can generically give an overview of nature of the data collected and analyzed. Argumentation was done mostly through asynchronous dialogues among the stakeholders (only two encounters were carried through video-conference). The observed exchange of textual, visual and sonic materials enabled the participants to explore further the ideas under consideration and can also be viewed as a form of dialogue complementary to the process of argumentation referred to before.. Enactive activity involved the exchange of material that was intended to be part of the work. Therefore, only the materials that were approved through an argumentation cycle of proposals and commitments and that were labeled as acceptable creative products by at least one of the artists were considered to be the outcomes of enactive activity.

Fig. 4 Creativity support metaphors for asynchronous decision-making: designing AV sketches.



The procedural depiction of the *Palafito* study is structurally similar to study 1. Local data, in this case representations of source sounds and footage, were shared through creative surrogates. The AV sketches provided a temporal reference system for the asynchronous decision-making process. Given the collective character of the endeavor, a common reference system becomes a requirement. Local decisions can only be made if the stakeholders have access to the status of the other participants. This study made use of volatile resources – in the form of AV sketches – to

increase the flexibility of the exchange, reducing its ecological impact.

Creative results

The study yielded the multimedia installation *Palafito/Palafita/Home-on-stilts*. Its first exhibit was held at the Floor4Art venue in Manhattan, New York. The exhibit took place during the month of November 2012 and ended with a closing gathering on December 1. The second exhibit took place in Denver, CO, USA, at the Museum of the Americas from June to September 2013.

The sculpture featured three 5x8x3-meter metal and wood vertical structures hanging from the ceiling and placed on the floor of the installation space. Three audiovisual tracks, lasting 6:30 minutes each, were played as loops on two stereo and one mono playback modules. The single-track module consisted of a DVD-player and a directional speaker (house 3). The speaker was attached to the ceiling, pointing straight downward, and the sound beam was adjusted to span a radius of approximately one meter, creating an isolated sound field. The video footage was displayed on a 10" LCD screen. The two stereo modules featured video projectors attached to the ceiling, facing opposite walls (houses 1 and 2). Two DVD-players sent audio to two sets of speakers hanging from the walls at a height of 2.5 meters, matching the locations of the projected videos.

The layout of the installation was designed to allow the visitors to walk freely within the gallery space. Consistently with other ecologically grounded creative endeavors (Keller 2000), the actions of the visitors were considered a central component of the artwork experience. Depending on the locations of the participants, different combinations of visual and sonic content were available. The house 1 module defined a sound field constrained to the sound beam area. Thus, the listeners had to be standing in front of the module to access the sounds. The sound fields corresponding to house 2 and 3 were audible throughout the gallery space. But given the different distances from the sources, visitors were free to design their own mixes by exploring the multiple perspectives afforded by the space.

3 Implications for the development of creativity support metaphors

We discussed two exploratory design studies - involving complete creative cycles - which yielded public presentations of artistic products. The first study targeted the use of local visual resources to produce audiovisual trackers for a mixed media performance.

The deployment of the creativity support metaphor *graphic-procedimental tagging* called for the participation of two musicians who employed the visual data – structured as an audiovisual score – as continuous pitch and onset-duration parameters. Execution time was directly correlated to the spatial position of the tracker on the score. The flowers' colors extracted from the original picture – pink and yellow – were repurposed to separate the instrumental sources. The sources were chosen ad libitum by the musicians. Pitch content was indicated by the distribution of the flowers' colored markings on the vertical axis, dynamics being defined by the markings' widths. An unprocessed recording done on site, following the traditional soundscape methods (Truax 2002), was used to define the total duration of the piece.

The second project, a large-scale installation commissioned to the Capasso+Keller+Tinajero Collective by the II Biennial on Latin American Art, was presented at the Denver Museum of Latin American Art and at the Floor4Art Studio Space in Manhattan, New York. The artwork featured three sculptural objects and three video and audio tracks that made use of ecologically grounded techniques to process Western Amazon audio and visual footage. The layout of the installation was designed to foster an active engagement with the multimodal elements of the piece. Visitors were encouraged to walk through the space to experience multiple combinations of sound fields. Following an ecologically grounded creative practice (Burtner 2005; Gomes et al. 2014; Keller 2000), the actions of the visitors were used to support the decision-making processes that shaped the aesthetic experience.

The results yielded by both studies indicate a recurring strategy in ecologically based creativity support metaphors. The projects discussed in this paper employed creative surrogates as material resources to support aesthetic decisions. The comparison of the processes involved in the two studies reported strongly suggest the existence of two distinct modes of usage of creative surrogates for the scaffolding of the different decisions involved in the creative processes. The first model is tied to the synchronous nature of the musical activities under scrutiny. Synchronous musical activities demand a single temporal representation to interpret the visual data. In *Tocaflor*, this visual data was used as a trigger for human performance of musical events by means of an *audiovisual tracker*. Contrastingly, audiovisual sketches serve as material proxies for distributed resources, supporting decision making through a shared symbolic representation of time that can be accessed remotely by all stakeholders. In *Palafito*, asynchronous activities featured *audiovisual sketches* as creative surrogates. While the latter model can handle the participation of non-musicians through unstructured exploratory actions within

the installation space, the former model necessarily targets musicians that have the expertise to use the AV trackers' visual information as a guide for bodily actions.

Given the use of local resources as materials for creative actions, both models abide by the directives of ecologically grounded creative practice (Keller 2012; Keller et al. 2014c). Nevertheless, only the audiovisual-sketch model meets the usability demands of ubiquitous music ecosystems (Lazzarini et al. 2014b) providing support for casual, untrained users. Audiovisual trackers require trained musicians that can synchronize their actions to complex visual cues with little look-ahead time. This type of decision-making activity places high demands on cognitive resources, hence it probably demands automatic mechanisms that are typical of expert performance (Shanteau et al. 2002). AV trackers fit the narrow view on embedded-embodied musical cognition that links musical activity exclusively to bodily actions (Nijs et al. 2009). In order to enhance the range of applications of AV trackers for everyday usage, some adjustments are necessary.

Firstly, both collocated and distributed musical activities need to be supported. By incorporating synthesized sounds through sonification techniques (Serafin et al. 2011), AV trackers do not need to rely on collocated human actions for sound rendering. Remote stakeholders may assess the musical results by making local changes to the AV tracker. A shared consistent representation – akin to a musical prototype (Miletto et al. 2011) – may reflect the stakeholders' proposals. To avoid intensive usage of bandwidth, rather than video formats, the system needs to support local sound rendering. In this scenario, all data exchanges may be done using standard still images.

Secondly, temporal synchronization among remote resources can only be accurate through asynchronous mechanisms (see Barbosa 2010 for a discussion on the limitations of traditional performance approaches to network-based musical activities). Sonic events do not need to be synchronous, they only need to be *perceived* as synchronous. This subjective perception of synchronicity can be attained by aligning the events to the local clock. A fit metaphor is provided by the theory of relativity: there are as many different times as there are space-time reference systems. For example, two stakeholders participating at a local (A) and at a remote location (B) produce two sequences of events. Stakeholder A adopts clock A as her frame of reference to generate a sequence A. Stakeholder B adopts clock B to produce a sequence B. For instance, in order to synchronize the sequences A and B, the remote clock needs to be adjusted to the local clock. Thus, if clock B is slower than clock A, sequence B needs to be accelerated to fit sequence A's temporal frame. Also, sequence B's onset needs

to be aligned to match the onset of sequence A. For AV trackers, this implies a two-stage procedure: (1) the local system calculates the difference between clock A and clock B yielding a time-difference index; (2) this index is used to adjust the speed of the AV tracker. In a hypothetical scenario in which the infrastructure handles the visual information and the meta-data separately, no exchange of audio or video material is necessary. Hence, sonification-based audiovisual trackers can bypass the requirements of computationally demanding audio-event recognition systems.

4 Conclusions

The two exploratory design studies reported in this paper yielded two instances of creative surrogates as viable support mechanisms for creative musical activity. Audiovisual trackers can be used to support synchronous, collocated decision-making activity. Audiovisual sketches are useful for asynchronous activity or when stakeholders and resources are not collocated. AV trackers demand domain-specific skills that may not be attainable by casual users. Contrastingly, AV sketches have good potential for untrained stakeholders. Thus, they enlarge the palette of support techniques for everyday creative practices.

Acknowledgements.

This research was partially funded by CNPq grants 455376/2012-3, 407147/2012-8, by the Lower Manhattan Community Council, New York, USA (Artist Grants 2012, 2013), and by Maynooth University, Ireland.

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The Emergence of Complex Behavior as an Organizational Paradigm for Concatenative Sound Synthesis

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Keywords: Audiovisual system, distributed agent system, emergence, concatenative sound synthesis, interactive musical improvisation.

Multi-agent systems commonly exhibit complex behavior resulting from multiple interactions among agents that follow simple rules. In turn, complexity has been used as a generative and organizational paradigm in audiovisual works, exploiting features such as behavioral and morphological complexity with artistic purposes. In this work, we propose to use the Actor model of social interactions to control a concatenative synthesis engine called earGram in real time. The Actor model was originally developed to explore the emergence of visual patterns. On the other hand, earGram was originally developed to facilitate the creative exploration of concatenative sound synthesis. The proposed integration results in the emergence of complex behavior from the Actor model acting as an organizational paradigm for concatenative sound synthesis.

1 Introduction

Natural systems such as insect swarms, the immune system, neural networks, and even chemical reactions (Bak 1995, Kauffman 1995, Camazine 2003) are widely considered to exhibit complex behavior arising from multiple local interactions among agents following simple rules. The self-organizing behavior of social animals (Reynolds 1987) has been used to explain certain social interactions, including in human society (Ulanowicz 1979). Interestingly, the emergence of complex behavior in computer simulations of natural systems has been explored aesthetically as organizational paradigm in artistic settings such as dance (Tidemann 2007), audiovisual installations (Beyls 2012), sound and music (Miranda 1994, Blackwell 2002, Caetano 2007), and sculpture (Todd 1992), among others.

In contrast to top-down design in most cultural artifacts, natural systems exhibit patterns arising from multiple local interactions among individuals or entities that do not exhibit the patterns themselves. From the stripes of zebras to snowflakes and termite mounds, pattern at the global level emerges solely from interactions among lower-level components (Camazine 2003). Much research in the discipline of artificial life studies life-like emergence in forms of synthetic biology (Langton 1997). Recent work in artificial chemistry (Dittrich et al. 2001) offers a wealth of models for constructing emergent behavior. For example, the idea of molecular interaction may successfully underpin complex musical human-machine interaction (Beyls 2005). Various music systems were built exploiting swarming behavior (Blackwell and Bentley 2002) – a model first formalized in the original flocking algorithm (Reynolds 1987). Miranda (1994), in turn, proposes to use the patterns that emerge from cellular automata in music composition. Caetano (2007) exploits the self-organizing dynamics of different algorithms inspired by biological systems to obtain trajectories that drive sound transformations.

In this work, we propose to use the complex behavior that emerges from a multi-agent system called the Actor model to drive earGram, a concatenative synthesis engine, in real time. The Actor model of social interactions uses the concepts of affinity and to iteratively displace the agents, called actors, to different settings of social stress. The self-organizing nature of the Actor model results in intricate visual trajectories followed by the actors. These trajectories, in turn, are used as input to earGram, a concatenative sound synthesis engine. EarGram organizes a collection of sounds in the plane according to their intrinsic perceptual qualities, such that neighboring sounds are more similar than sounds that are far apart. Therefore, spatial trajectories result in

sonic trajectories that become gradual transformations along the perceptual dimensions used to organize the sounds. The user can choose the sound features corresponding to the dimensions of the space, which results in different configurations of the sounds in the plane. Consequently, the same trajectory can have several different sonic results.

Our goal is to build a system supporting non-trivial rewarding human-machine interaction. In contrast to conventional linear mapping, the user interacts with the Actor model indirectly by changing the affinity and sensitivity values, which results in different dynamic configurations. The system dynamics becomes the organizational paradigm followed when exploring the conceptual space of sonic results. The actors behave autonomously from the specification of simple local instructions, yet the system is open to disturbance by an external human performer (HP), offering fascinating aesthetic potential for human-machine interaction. Then, a perception of life-like qualities becomes apparent, one interacts with a quasi-unpredictable system while the structural integrity of that system remains. Such a work suggests critical consideration of the notions of interactivity, intricacy, participation and unpredictability.

This paper is further structured as follows, firstly we explain the Actor model and its behavioral scope, then we address concatenative sound synthesis in earGram. Finally, the implementation of a functional bridge between both components is presented. We discuss the visual and sonic components of the system, including aesthetic considerations and user interaction.

2 An Emergent Organizational Paradigm

Linear top-down planning and design suffers from a knowledge acquisition bottleneck. In contrast, collective behavior commonly presents self-organizing properties whereby pattern at the global level emerges solely from interactions among lower-level components. Remarkably, even very complex structures result from the iteration of surprisingly simple behaviors performed by individuals relying only on local information.

2.1 The Party Planner Model

Our implementation is inspired by the Party Planner Model (PPM), developed by Rich Gold and documented in his seminal book *The Plenitude* (Gold 2007). Imagine a party where each individual aims to be physically close to people one likes and as far away as possible from people one dislikes. An individual's level of unhappiness is the perceived social stress impinging at a particular location

$$S_A = \sum_{n=0}^{N-2} |D_i - D_a|$$

eq. 1

in physical space. Formally, given N actors, the level of unhappiness of actor A at index i is expressed in eq. (1) as the sum S_A of absolute values of the differences in ideal distance D_i minus actual distance D_a for all $(N-2)$ actors. An actor does not express any social opinion towards itself, thus $N-2$ evaluations take place starting from index 0.

Every person aims to minimize his/her level of unhappiness by moving in space, to a neighboring spatial location, a few steps away from the current location, potentially offering less social stress. As a result, a person will relocate to his/her ideal distance from every other person thus minimizing the total perceived level of unhappiness.

In every process cycle, all actors consider eight alternative directions to move, as depicted in Figure 1. A list of different social tensions is computed from the observation of the grand sums of impinging stress. Finally, the algorithm favors the direction to move implying the least stress of all eight directions. All actors proceed according to the same logic. However, actions by individual actors only observe local social concerns i.e. the evaluation of stress towards the closest neighbor. As a result, the process proceeds as an animated sequence of globally complex spatial configurations. In addition, conflicting requirements may contribute to highly non-linear behavior. For example, actor A may prefer to be close to actor B while actor B aims to be far away from actor A . Merging this local concern with impact from neighboring actors, complex following or push-pull oscillatory behavior might emerge. One may think of PPM as a complex dynamical system that, according to the specification of particular social preferences, will produce spatiotemporal patterns of considerable intricacy.

2.2 The Actor Model

An extended version of the PPM called *Actors* has been used to simulate collective musical improvisation (Beyls 2010). In this work, we propose to use the Actor model as *organizational paradigm* in concatenative sound synthesis. In the Actor model, the user does not control the system. Instead, the user influences the outcome of an otherwise self-organizing social system. In other words, we interfere with the system's innate behavior in two possible ways. First, a HP virtually present interacts with the actors who, in turn, acknowledge the HP's social preferences. The HP interacts with the system via a control interface (e.g., MS's Kinect or Nintendo's Wii) that maps the actions into the space. The system is influenced only locally but might entail the emergence of complex patterns. The other possibility is to have the HP conceptually outside

the actor society but able to adjust global parameter settings. So the interaction happens via the parameter settings of the system. The current implementation, reported here, documents the sec-

Fig. 1a Representation of the affinity matrix.

	A_1	A_2	A_n	A_N
A_1	0	$a_{(1,2)}$	$a_{(1,n)}$	$a_{(1,N)}$
A_2	$a_{(2,1)}$	0	$a_{(2,n)}$	$a_{(2,N)}$
A_n	$a_{(n,1)}$	$a_{(n,2)}$	0	$a_{(n,N)}$
A_N	$a_{(N,1)}$	$a_{(N,2)}$	$a_{(N,n)}$	0

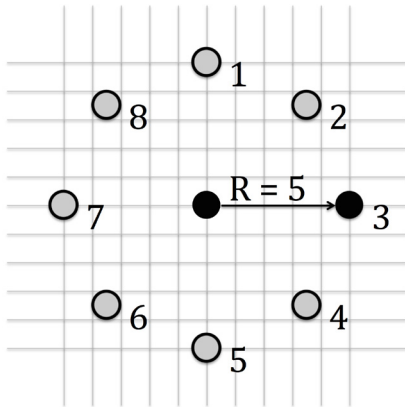


Fig. 1b Representation of moving actor.

ond method.

The dynamic scope of the system is conditioned by two parameters; (1) the *affinities-matrix* (Figure 1a) specifying the ideal distances of every actor towards every other actor and (2) a *sensitivity parameter*, a value local to every actor. Sensitivity level is a single scalar value, private to the actor. It specifies the actor's sensitivity to any other actor, irrespective of the sensitivity of the other actor. Sensitivity conditions a distance threshold that in turn conditions interactions with a list of temporary neighbors.

Intuitively, it is easy to see a connection between the range of values and their diversity of values in the matrixes and the complexity of the ensuing spatiotemporal behavior. For example, given roughly equal values in the *affinities-matrix*, all actors will relocate to be at equal distances.

In every process step, the affinities-matrix is consulted to compute a list of new potential positions according to figure 1b; eight potential locations, at a 5-pixels radial distance, are considered relative to the position of the actor. However, only actors that are close enough are considered neighbors, that is, when their distance is within the sensitivity range currently expressed in the sensitivity value of the perceiving actor.

A wide range of spatiotemporal phenomena is generated from the specification of individual matrix values. Such a control structure is aesthetically attractive because the HP has the impression of interacting with an intricate system, whose behavior is only partially understood. The causal link between matrix and behavior is non-trivial, however it is perfectly coherent and offers structural integrity. Although individual actor behavior is unpredictable, the system nevertheless offers a strong overall impression of coherent performance.

2.3 Mapping between human performer and system dynamics

Mapping aims to create specific functional relationships between gestural information and musical responses. Conventional approaches to mapping are deterministic yielding predictable results. Mapping typically generates musical responses as selected from a user-designed palette of options. For example, circular gestures always map to loudness changes. Given an aesthetic orientation favoring unpredictability and surprise, the concept of deterministic mapping is problematic. The Actor model suggests an alternative; the human performer interferes with the parameters affecting system dynamics - not unlike Sal Marirano commenting on him playing the SALMAR Construction: “it was like driving a bus” (Chadabe 1997).

Fig. 2 Spatial configurations resulting from different parameter settings for the Actor model

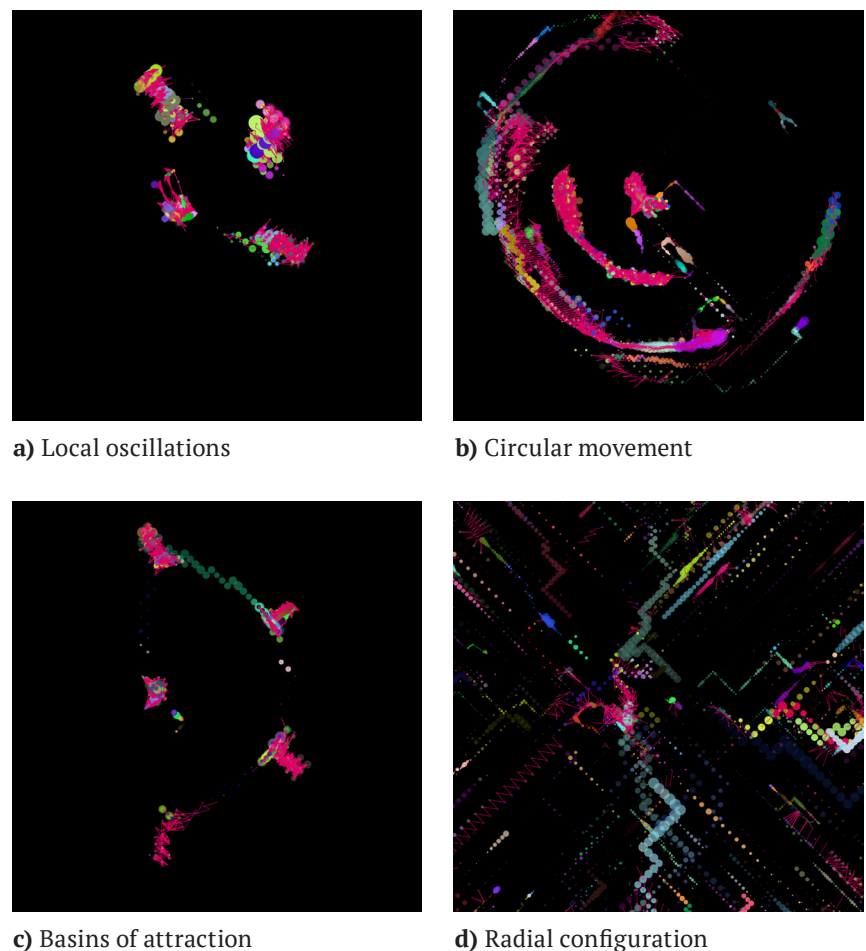


Figure 2 displays a collection of 4 snapshots, momentary spatial configurations as captured in a continuous animated process, window size is 1000 by 1000 pixels. Social affinities are set at random in the range of 50 to 500 pixels, whereas actor sensitivity is fixed (at a radius $R = 5$ pixels) in this experiment. Each image displays the configuration after 100 iterations (typically more),

illustrating how different complex spatial configurations might emerge from different affinities. Only the affinities-matrix is occasionally slightly modified while the process is running.

In Figure 2a, all actors coalesce into four specific locally oscillating configurations. The effect of the forces of attraction and repulsion merges into a stable spatial pattern. Circular movement is clearly seen in Figure 2b with parallel trajectories showing evidence of attraction and repulsion cancelling out. Five major islands of activity emerge in Figure 2c while a spatial explosion occurs in Figure 2d.

Figure 3 illustrates the spatiotemporal behavior of 10 actors in a total agency of 50. The vertical axis shows the position along the X-axis and the horizontal axis shows iterations. We explore the behavioral scope of the system through interactive modification of the affinities-matrix. As the actors interact their trajectories oscillate between quasi-periodic and irregular. We end up having a control structure of high *plasticity*, its spatiotemporal complexity morphologically blending in the sound application to be discussed in the next section.

The Actor system implies two presentation modes; as a large-scale, projected real-time audiovisual installation and as a machine-mediated solo performance. It is implemented in two concurrent processes, agency behavior, parametric control and visualization is written in JAVA. A second process handling sound synthesis receives control data from the Actors via Open Sound Control (Schmeder et al. 2010).

3 Musical Application

In this section, we briefly introduce concatenative sound synthesis and earGram, the application used in this work. The discussion covers how the sound features capture perceptual qualities of the sounds, how to create sound spaces using the features as dimensions, and how different spatial configurations of sounds result from different dimensions.

3.1 Concatenative Sound Synthesis

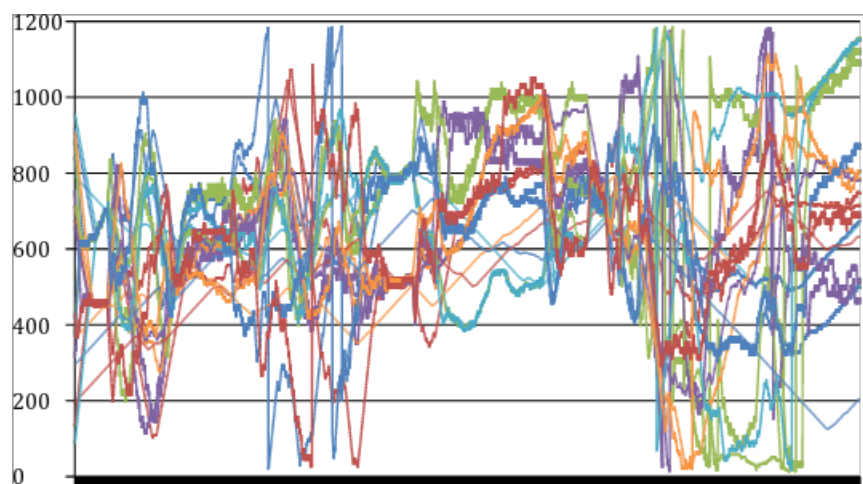
Historically, concatenative sound synthesis (CSS) can be grouped with other sample-based techniques such as micromontage and granular synthesis which originated from the early *musique concrète* experiments. Briefly, CSS creates “musical streams by selecting and concatenating source segments from a large audio database using methods from music information retrieval” (Casey 2009). To a certain extent, CSS can be understood as being an

extension of micromontage and granular synthesis towards a higher degree of automation.

What's unique about CSS in relation to other sample-based techniques is the annotation layer of the segments database, which not only provides the user with a good description of the audio source content, but also allows him/her to adjust, organize and re-synthesize the temporal dimension of the source in refined ways. Segment annotations include features automatically extracted and grouped into a single vector with the help of low-level audio descriptors, in a similar fashion as the audio-annotation layer of the MPEG-7 standard (Kim et al. 2005).

The sonic output of CSS systems depends on the audio descriptors used to organize the audio segments. The descriptor values define the spatial configuration of the segments, defining neighborhood relations and relative distances. For example, two segments might present similar loudness values at different pitches, which would place them close together along the loudness dimension but far apart along the pitch dimension.

Fig. 3 Illustration of the spatiotemporal behavior of the Actor model. The vertical axis represents the position of each agent, while the horizontal axis represents the iterations. The curves illustrate how the trajectories can oscillate between quasi-periodic and chaotic paths, revealing intricate patterns.



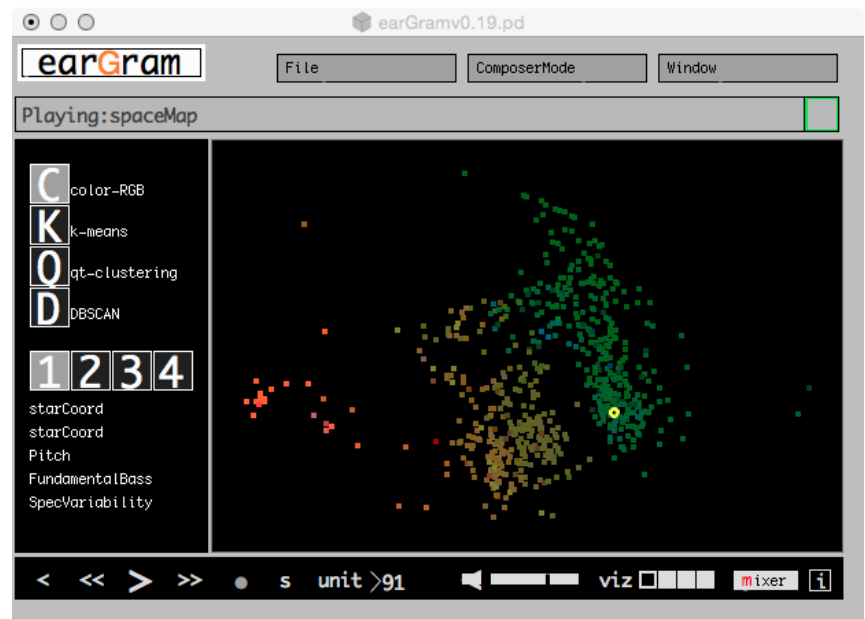
3.2 EarGram

EarGram (Bernardes 2013, 2014) is an open-source and freely available application created in Pure Data for the real-time creative exploration of concatenative sound synthesis (CSS).¹ EarGram extends CSS, first attributed to Schwarz (2000), with new possibilities for generative audio by adopting strategies from both algorithmic-assisted composition and music information retrieval (MIR). The latter strategies are responsible for (i) segmenting an audio stream into elementary units, (ii) describing the most relevant features of the segments, and (iii) extracting patterns from the resulting collection of segments. Additionally, the system unpacks MIR terminology and concepts to a more adapted usability for musicians by relying on musicological and psychoacoustic

¹ The software along with its documentation and many sound examples are available at: <https://sites.google.com/site/eargram/>.

theories, and presents most of processing stages of the systems in an intuitive manner, mainly through visualizations. The set of MIR tools adopted in earGram constitutes a valuable aid for decision-making during performance by revealing musical patterns and temporal organizations of the database, which are then used to represent audio in common algorithmic-assisted composition techniques.

Fig. 4 2D plot of the speech sound database used in musical component of the system.



EarGram includes four generative modes: spaceMap, sound-scapeMap, infiniteMode, shuffMeter, which cover a wide range of musical applications, such as the automatic generation of sound-scapes, remixes, and mashups, to cite a few. Of interest here is the spaceMap mode, which is used to interact with the Actor model adding a sonic layer that offers musical functionality. The interface of spaceMap is shown in Figure 4 as a plane whose axes can be assigned to single audio descriptors or linear combinations of them. For example, the vertical axis might be loudness and the horizontal axis might be pitch. Each sound segment is represented by a (square) point in space, and their spatial organization is defined by their sound qualities (as measured by the descriptors). The visual representation of the database is used to play sound segments in the descriptor space as spatial trajectories. Hovering the mouse pointer (round point) plays the sound that is closest in the space. So, in the example, sliding the pointer vertically upward would play sounds that are louder and horizontally to the right would play sounds higher in pitch. Diagonal upward right-hand movement would play sounds with increasing pitch and loudness. While small movements synthesize similar sounding segments, larger movements pick sounds with greater sonic

differences. SpaceMap allows the creation of highly controllable sonic textures driven by the user.

4 Using the Actor Model to Drive earGram

4.1 Speech Sounds as Metaphor for Social Interaction

Following the concept behind Gold's PPM's and the Actors model, we chose to work upon a database of multi-linguistic speech sounds to better express the idea of social interaction in the musical component of our system. Our aim was to represent social interaction, and particularly the affinity among individuals, by the perceptual proximity of speech sounds. Meaning that if the Actors' "society" reaches a stable configuration, the sonic response of the system should reduce the amount of variation to a minimum and, on the contrary, highly deviating configurations should result in a high level of sonic variation. Between these two poles there is a map that regulates the degree of variation in the speech sounds.

The speech sounds were retrieved from the UCLA Phonetics Lab Archive,² which includes both native female and male speakers of different languages, such as Bulgarian, Dutch, Estonian, Javanese, Nepali, Portuguese, Zulu, among others. After some basic sound editing to improve the sound file quality, including filters, equalization and noise removal, earGram automatically segmented the collection of speech sounds into short snippets of 200 ms each. Then, we solved the most crucial pre-processing stage of our database creation: the selection of a set of audio descriptors to represent our segments in the system.

The analysis of the database segments comprised two main tasks. First, we manually restricted the set of available audio descriptors to a sub-set of audio features that included: noisiness, pitch, brightness, spectral width, and sensory dissonance. Then, we weighted the set of selected audio descriptors to adjust their contribution in the feature space. Weights were automatically assigned according to the computed variance of each of the selected descriptors. By reducing the number of audio descriptors and weighting their contribution, we not only discarded redundant information for the analysis of speech segments, but also enhanced the computation of their perceptual similarity, which consequently improves their visual representation on the interface.

In order to plot the segments represented by their multidimensional vectors in a 2-D space, allowing to physically navigate their representation, or for the purposes of this work, to map to the 2-D visual representation of the Actor model to our space, we reduced the dimensionality of the segments' features vector to two

² <http://archive.phonetics.ucla.edu>, last access on 7 January 2015.

dimensions using the algorithm star coordinates, first proposed by Kandogan (2000) and used in the scope of CSS by Bernardes et al. (2013). Figure 4 shows a 2-D plot visualization of the database whose axes are a linear combination of the aforementioned audio descriptors.

4.2 Integrating the Systems

After the database creation, we tackled the mappings between the Actor model and earGram's spaceMap, i.e. the visual and musical components of our system. In spaceMap, synthesis is typically controlled by defining trajectories in earGram's interface with the mouse. EarGram then retrieves the closest unit to the mouse position and synthesizes the selected segment with a Gaussian amplitude envelope. In our work, we replaced the mouse control by the position of each Actor in the space, given by its X and Y coordinates. This rather simple mapping strategy is effective in the sense that the segments plotted in the spaceMap interface are organized according to their perceptual distance. Therefore, Actors with high affinity values are close together in the descriptor space, so they will trigger similar sounding units, resulting in affinity being related to perceptual similarity. A video with an example of the final system is available at <https://vimeo.com/118500562>. In this example, there are 50 actors, the affinity matrix was initialized with low values, and the sensitivities are initialized all at 5 pixels.

Given the large amount of data sent to earGram via the OSC protocol, we ran into both technical and aesthetic problems related to the rate of transmitted data. Not only did the network block information in unclear ways, but also large amounts of data were incompatible with our sample-based technique, resulting in a constant over saturated mass of synthesized grains. To minimize this problem, we adjusted both the video frame rate to 25 frames per second (the same rate at which the location of Actors is computed) and imposed a different clock to control the rate of data sent over the network (every 800 ms).

Given the large number of data points received every 800 ms, we decided to store the Actors' location in memory and sequentially read them at equidistant time intervals within the 800 ms. Therefore, we hear a new segment every n ms, which equals the total number of Actors divided by 800 ms. Finally, we added an extra processing layer that looks at the overall stability of the Actors in the space, computed by measuring the flux of information at every received package of information, and mapped the value to the wet-dry parameter of a spectral freeze audio effect based on Paul Nasca's Extreme Sound Stretch algorithm³ in earGram.

5 Discussion

A user engages with the proposed system mainly via modification of the parameters (global affinity matrix and local sensitivity values) in the Actor model, exerting influence on the dynamic behavior of the system. This indirect method for influencing the system behavior has implication on both the visual and sonic components of the system along two conceptual dimensions, level and extent of activity. The level of activity is related to the displacement of the actors, ranging from stationary to highly dynamic. The extent of activity refers to the distribution of the actors in the plane, which can vary between highly concentrated and spread out.

However, other decisions also influence the sonic outcome, such as selection and pre-processing of the sound source material, selection of the features used to define the dimensions of the space in earGram, and the affinities and sensitivities for the Actor model. In general terms, the source material determines the range of sonic possibilities. Speech sounds will produce a different outcome than instrumental, environmental, or synthetic sounds. The features have a direct impact on the distribution of the sounds in the plane in earGram. Changing the features will reorganize the same sounds according to different perceptual similarities, such that the same trajectory will generate a different sonic outcome. In this section, we will discuss the impact that each decision has in the aesthetic result.

In general terms, the spatiotemporal behavior of the system is determined by the level of social stress, which, in turn, depends on the magnitude and homogeneity of the affinities and sensitivities. High affinities result in strong attraction between actors, while low affinities generate repulsive forces. Homogeneity in the affinity matrix also impacts the global dynamic behavior. Whenever the user sets all the affinities to the same value, the level of activity decreases resulting in point attractor behavior. Heterogeneous affinity values entails complex dynamic behavior. The sensitivity also plays an important role in the dynamic behavior of the actors because it determines the radius R of influence of the affinity values $a_{(n,m)}$ between Actors A_n and A_m (see fig. 1a). High sensitivities force the actors to consider distant neighbors, while low sensitivities cause the actors to only interact with nearby neighbors.

For example, high magnitude homogeneous affinity values with high sensitivity will likely result in all actors clustered in a point because they are all highly attracted to one another. Low magnitude homogeneous affinity with low sensitivity will likely result in a uniformly spread out configuration across the plane because all actors are equally repulsed by their nearby neighbors. Notice

³ <http://hypermammut.sourceforge.net/paulstretch/>, last access on 7 January 2015.

that both scenarios result in low levels of activity because the examples suppose a homogenous affinity matrix and nearly equal sensitivity values. Highly dynamic complex behavior is commonly achieved through heterogeneous affinities and sensitivities.

The sonic response depends on the level and extent of activity as well. On the one hand, the level of activity is responsible for the dynamic response of the system. Each spatial trajectory results in a sonic trajectory that translates as temporal variation of the corresponding sound texture. On the other hand, the extent of activity influences the diversity of the sonic response by exploring different regions of the sound space.

The level of social stress drives the visual and sonic components of the system in symbiosis. The more complex chaotic oscillatory behavior of the actors, the more heterogeneous is its sonic response. Stable configurations result in sound textures with little variation. In other words, the actors' dispersion is related to the variability or "spreadness" of the sound segments selection, which equate with the level of coherence of the resulting texture, due to the organization of the segments on earGram's feature space. In between the two poles a wide and virtually endless range of possibilities exists.

Another interesting feature of the matrix-based control structure is the synthesis of smooth trajectories when one of more values fluctuates in the sensitivities-matrix. Since actors move through the consideration of a step-by-step evaluation process, changes gradually accumulate towards a spatial niche of lower social stress—the pull towards the basin of minimum stress decreases as a function of the distance of the actor from that location. In addition, considering one actor, since all its neighboring actors are all engaged in the same process, global behavior crystallizes into trajectories of considerable plasticity—the system produces smooth waves of spatiotemporal patterns. These smooth trajectories of actors in the visual domain are then mapped to the pointer position responsible for selecting audio segments in earGram's organized database visualization. The resulting sonic feedback matches the dispersion/cohesiveness and continuity of both the overall visual representation and the trajectories of individual actors. Furthermore, stable spatial configurations of the Actors society is further distilled into a blurred sonic texture obtained through spectral "smoothing" and filtering. The longer the actors' inactivity, the blurrier the texture becomes and the fewer spectral peaks are synthesized, thus reinforcing in the sonic domain the spatial configuration of the visual component of the system.

A fundamental contribution of this work in relation to its previous version, or for this matter any related work in auditory display and sonification, is the use of concatenative sound synthesis, an

innovative sample-based synthesis technique, at the core of the software earGram. The integration of earGram with the Actor's model not only offered us more plastic and expressive sonic results in relation to related approaches—which tend to focus on additive, subtractive or physical synthesis models—but also allowed us to better match the conceptual basis of the system through the synthesis of speech sounds. By adopting a fixed database configuration in earGram, we favored one robust solution over a myriad of possibilities offered by the system. However, the current integration of both systems allows a user to easily experiment with different audio sources or even different feature spaces (i.e. database organization in the interface), while maintaining the same structural mapping, interactive behaviour, and to a certain extent the aesthetic basis. While adopting a different audio source has a greater impact on the sonic result, changing the feature space that organizes the audio segments database will offer a lower degree of variability, which equates in musical terms to the creation of variation of the same musical material. Ultimately, the positive outcome of this work spurs experimentation on sample-based techniques driven by a-life behaviour.

6 Conclusion and Future Work

Multi-agent systems commonly exhibit complex behavior after multiple local interactions following simple rules. The dynamics of self-organizing systems has been extensively explored aesthetically in artistic settings. Here, we use the Actor model of social interactions to control a concatenative synthesis engine called earGram in real time. The self-organizing behavior of the Actor model was designed to be aesthetically interesting visually, exploring the space as complexity emerges from the interactions. This visual complexity is used to aesthetically explore the feature space in earGram, whereby spatial trajectories become gradually evolving sonic textures. Trajectories are a powerful way to control earGram creatively because the spatial configuration reflects perceptual relationships among the sounds. The Actor model provides multiple trajectories, each controlling a sound texture in parallel, which result in an intricate and ever-evolving sonic tapestry.

User interaction is essential to explore the sonic result. Currently, the user interacts with the system by changing the parameters affinity and sensitivity that control the dynamic behavior of the Actor model. We plan to enhance the interactive feedback loop with a gestural device, such as MS Kinect. The gestures can be used to change parameter values in real-time. The sonic feedback would be used as system response to the interferences. The

performer affects the visual and sonic output indirectly since the gestures do not control the system configuration, only the system parameters. More interestingly, the human performer can use a virtual presence device to interact directly with the actors. In this case, the human performer becomes the external perturbation that continuously upsets the states of equilibrium of the system driven by aesthetic judgments.

Acknowledgements

Research reported here is supported by MAT, The Media Arts and Technologies Project, NORTE-07-0124-FEDER-000061, and financed by the North Portugal Regional Operational Programme (ON.2 O Novo Norte), under the National Strategic Reference Framework (NSRF), through the European Regional Development Fund (ERDF), and by national funds, through the Portuguese funding agency, Fundação para a Ciência e a Tecnologia (FCT).

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Shaping Microsound Using Physical Gestures

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Keywords: sound synthesis, parameter mapping, fuzzy logic, dynamic stochastic synthesis.

This paper presents a system for controlling the structure of synthesized sounds at the waveform level using physical gestures. The purpose of the system is to allow intuitive, natural, and immediate interaction with a sound synthesis model based on a non-standard synthesis technique. Instead of manipulating numerical parameters which are, in case of non-standard synthesis, typically abstract and without acoustical meaning, musicians can shake a mobile device in order to shape the structure of synthesized waveforms. The system receives raw data captured from accelerators, extracts relevant statistical features, and maps them into parameters of a dynamic stochastic synthesizer. Mapping is based on fuzzy logic in order to ensure a non-linear and non-injective relation defined within explicit mapping rules. Experimentation proves that the system provides natural, immediate, and expressive control which is convenient both in the composition process and in live performances.

1 Introduction

Sound synthesis using analog and digital electronic devices allows composers to create novel sonorities that characterize their compositions uniquely. Controlling the timbre and its changes over time is an important compositional aspect which provides coherence between musical form, structure, and material (Manousakis, 2009). Stockhausen emphasized that “every sound is the result of a compositional act” (Stockhausen, 1963), while Di Scipio wrote that “synthesis can often be thought of as micro-level composition” (Di Scipio, 1995) referring to the idea that sound synthesis allows composing timbers instead of just employing them in higher-level musical structures (Brün, 2004).

Sound synthesis techniques particularly oriented to the micro-level composition and sound microstructure are non-standard methods (Thomson, 2004). Instead of relying on theoretical acoustical models, reproduction of actual sounds, or psycho-acoustic phenomena, non-standard synthesis methods are based on mathematical models and compositional abstraction (Holtzman, 1979). Such an approach allows composers to describe waveforms, their organization and transformation, without imposing their acoustical consequences. Thereby, many compositional aspects are reduced to controlling the sound synthesis process and creating sounds at the waveform level.

Non-standard techniques, idiomatic to digital sound synthesis, attracted the attention of researchers and composers, especially in the 1970s. Even though most of the non-standard techniques produce sounds by generating waveforms in the time domain, several principally distinct approaches emerged: synthesis based on rules (Berg, 1979; Berg, Rowe and Theriault, 1980, Brün and Chandra, 2001; Holtzman, 1979), stochastic approach (Xenakis, 1992), fractal interpolation techniques (Yadegari, 1991; Monro, 1995; Dashow, 1996), and other approaches (Valsamakis and Miranda, 2005; Collins, 2008).

Since non-standard synthesis techniques are not focused on acoustical features of the synthesized sound, their controllable parameters usually do not bear acoustical meaning. The parameters serve as abstract numerical inputs of mathematical models for waveform generation. In order to achieve desired waveforms, composers need to understand all the details of the applied synthesis model and its capabilities. While this is not a limiting factor for composers who developed the synthesis models themselves, the lack of intuitiveness may negatively affect the efficiency and inspiration of those who do not use their own models. The process of shaping micro-sound should be closer to the way how composers imagine sound structures. A more intuitive way of

controlling parameters of non-standard synthesis models would allow composers to think within the musical domain during their creative process. Additionally, such an approach would be more convenient for applications in which immediate control is needed, such as for live performances or interactive installations.

As a solution for intuitive control of non-standard synthesis techniques, we propose a system for detecting physical gestures and mapping them into sound synthesis parameters. Physical gestures as a means for controlling the process of sound generation are already widely used in the area of dance-music inter-modalities and applications related to enhancing musical content by physical actions (Friberg, 2005; Heile, 2006). An advantage of physical gestures for composing at the micro-level would be the intuitive and immediate relation of natural movement with waveforms synthesized by non-standard models. Instead of manipulating numerical parameters, composers could achieve their ideas and develop unique expressivity by experimenting with physical movements. The system proposed in this paper extracts selected features from the physical gestures and maps them into synthesis parameters. The purpose of this mapping is to achieve natural relations between gestures and the structure of synthesized waveforms. Transitively, physical gestures may be also related to the acoustical features of the synthesized sound, but only to the extent to which synthesis parameters are related to acoustical features.

The system for shaping microsound using physical gestures described in this paper employs the dynamic stochastic synthesis as an underlying synthesis model. We selected this synthesis technique because it is purely parametric unlike some other non-standard methods which require setting up rules or initial states.

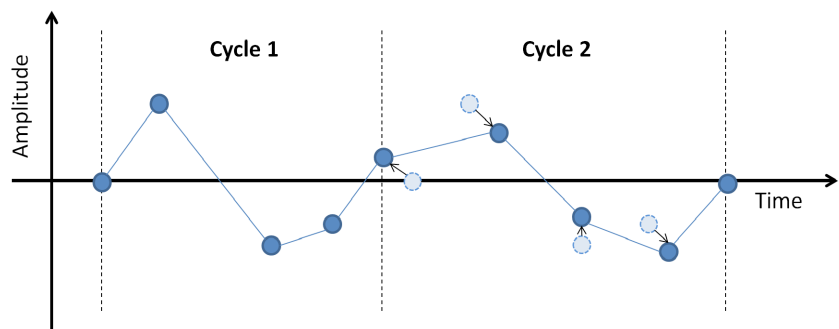
2 Dynamic Stochastic Synthesis

Before presenting the overall system, here is a short overview of the employed synthesis model. Dynamic stochastic synthesis was devised by Iannis Xenakis as a result of his ambition to achieve unified and simultaneous engagement on different time-scales within the composition, from the overall structure of the composition to its microstructure and tone quality.

Dynamic stochastic synthesis generates samples by interpolating a set of breakpoints which change their amplitudes and positions in time stochastically. A breakpoint position is represented relatively to the preceding breakpoint and it is commonly called “breakpoint duration”. Initial amplitudes and durations are usually chosen randomly or taken from a trigonometric function.

At every repetition of the waveform, these values are varied independently of each other using random walk. That means that both the amplitude and the duration of a certain breakpoint are changed by adding random steps to the values in the previous cycle as shown in Figure 1. A succession of random steps applied on all breakpoints causes the continuous variation of the waveform. The amount and character of the variation depend on a selected probability distribution and its parameters. Both amplitude and duration random walks are limited each with two reflecting barriers which bounce excessive values back into the predefined range.

Fig 1. Breakpoints change their positions from one repetition to another. Light blue circles in the second represent positions from the first cycle, while darker circles represent new positions.



These barriers prevent breakpoints from straying too far from their initial positions and therefore enable control over amplitude and frequency ranges of the overall waveform.

Parameterization of the synthesis model is achieved through: (1) the number of breakpoints in a waveform, (2) barriers of the amplitude random walk, (3) probability distribution of the amplitude random walk and its parameters, (4) barriers of the duration random walk, and (5) probability distribution of the duration random walk and its parameters. The amplitude barriers provide control over the amplitude range of the generated waveform, while the duration barriers define minimal and maximal number of samples between two breakpoints. If changes in amplitude and duration between successive repetitions are small, the synthesized sound is relatively simple, but it can have interesting modulation effects. On the other hand, as changes become more prominent, the sound becomes more complex and noisier.

Detailed explanations of the synthesis model can be found in (Serra, 1993) and (Luque, 2009), while several other researchers proposed extensions of the original algorithm (Hoffman, 2000; Brown, 2005; Young, 2010). Since the first implementation by Iannis Xenakis did not provide any means of controlling the synthesis process, some authors suggested interface designs for direct parameter control (Hoffman, 2000; Bokesoy and Pape, 2003; Brown, 2005). An interesting solution was also a mobile application which obtained parameters from multi-touch gestures and

accelerometers (Collins, 2011). In all of the mentioned approaches, the values from controllers or sensors were directly mapped into synthesis parameters which remained transparent to composers. In order to hide numerical parameters, in our previous research we proposed intuitive control by an input audio signal (Kreković and Brkić, 2012) and using MIDI messages (Kreković and Petrinović, 2013).

In this paper we present a novel approach focused on using physical movements for controlling dynamic stochastic synthesis and thereby for the intuitive shaping of synthesized waveforms. The following chapters describe the system design, experiments, and results yielded within this research.

3 System Overview

As has been mentioned previously, the main goal of this interactive system is to provide a simple and intuitive method for shaping waveforms by shaking a mobile device. Therefore, the central problem of the research is establishing natural mappings between the shaking gestures and the synthesis parameters.

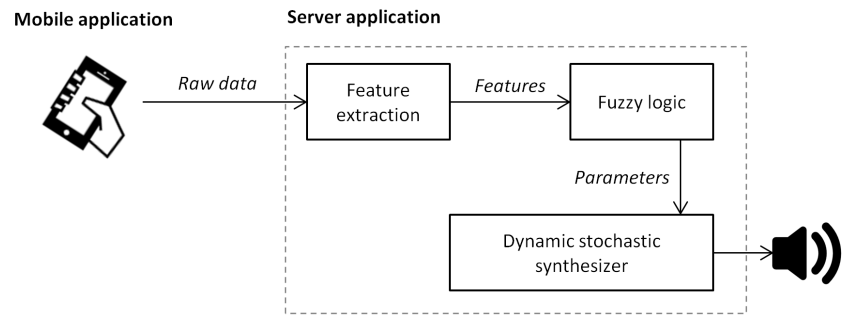
The first step was to choose features of the shaking gesture which could be extracted from the raw physical movements. Since the intention was to establish a relation between the features and the waveform structure, we searched for lower-level features which could not bear meaning, symbols, or metaphors. The information used for shaping microsound should be contained at the phenomenological level of the physical movement and not on the symbolic level. To cover cinematic, frequential, and spatial phenomenological aspects of physical movements we selected the following features as relevant for our study: intensity, frequency, and shaking direction.

In order to extract the aforementioned features using a computer system, the prerequisite is to capture raw physical movements and represent them as a stream of numbers. That functionality is available in a mobile application which serves as a controller. As the user shakes the mobile device, the mobile application captures data from accelerometers and sends them to the server side. The communication between the application and the server side is based on the Open Sound Control (OSC) protocol which is a widely-used and standardized protocol for networking sound synthesizers, computers, and other multimedia devices. This way, we can use any existing mobile application that can read data from accelerometers and form appropriate OSC messages. Besides the compatibility with many existing iOS and Android applications for smartphones, the implementation of the OSC protocol also opens opportunities for running client applications on different types

of devices such as smart watches and other wearable devices with accelerometers. There are countless possibilities when the use of such devices in performances is concerned.

The server-side application receives the raw data from accelerometers, extracts relevant features, maps those features into sound synthesis parameters, and finally produces an audio signal using dynamic stochastic synthesis. The mapping between features of the shaking gestures and synthesis parameters is a non-linear and non-injective mapping based on rules which can be elicited from knowledge of a human expert. To implement such a mapping we opted for an expert system based on fuzzy logic. The overall system architecture with corresponding data flow is

Fig 2. Overall system architecture and data flow.



shown in Figure 2.

3.1 Movement Analysis

Raw data from accelerometers represents instantaneous accelerations of the mobile device and do not quantify physical gestures directly. However, there are higher-level features extracted from the raw data that can better describe the nature of movements. Since the dynamic stochastic synthesis produces rich and complex sounds with organic quality, we opted for shaking movement as a gesture which can, to some degree, metaphorically represent the waveform structure and its acoustical qualities.

The first feature, which represents the cinematic phenomenological aspect of the physical gesture, was the shaking intensity. The intensity is calculated as the root mean square (RMS) of the acceleration changes for all three axes:

$$intensity = \sqrt{\frac{1}{3}[(a_x[n] - a_x[n-1])^2 + (a_y[n] - a_y[n-1])^2 + (a_z[n] - a_z[n-1])^2]}$$

where $a_x[n]$, $a_y[n]$, and $a_z[n]$ represent discrete values of acceleration respectively in the n -th step at the axes x , y , and z . In order

to smooth the spikes, a running average filter is applied to the calculated root mean square.

The second feature we selected was the measure of how fast the user shakes the device. We called this feature “shaking frequency”. This measure is calculated based on the number of zero-crossings. Each time that the motion of the device changes direction, the sign for acceleration on some axes changes as well. Therefore, the number of crossings through the zero value can be approximately correlated with the frequency.

The purpose of the third and final feature is to quantify how complex the shaking movement is. For simplicity’s sake, we call this measure “shaking direction”. If the user shakes the device just along one axis (e.g. up and down), this feature has a low value, but if the user makes loops and changes directions very often, the feature will have higher values. The measure is based on the maximal absolute difference between the acceleration changes on two axes in the same moment. A running average filter is again used to smooth spikes.

3.2 Fuzzy Mapping

The higher-level features are mapped into sound synthesis parameters according to desired relations to the synthesized waveforms. The intensity is intended to correlate with the amplitude and the structural complexity of the generated waveform. More vigorous movements of the device should cause higher amplitudes of the synthesized signal and more prominent changes of break-point positions. The shaking frequency is intended to be related to the frequency range and frequency drifts of the synthesized waveform. It should, consequently, affect the impressions of pitch and timbral flux. Faster movements of the device should result with smaller duration limits, greater frequency drifts, and shorter waveform cycles. Finally, the shaking direction is intended to control the dynamicity of the amplitude and the frequency changes of the waveform. Simpler movements of the device should cause steadier waveforms and simpler timbres, while loops and sudden changes of the shaking direction should cause faster developments of the waveform and thereby more complex timbres.

An expert system based on fuzzy logic was chosen as the most convenient solution for mapping gestural features into synthesis parameters. Fuzzy logic is a form of probabilistic logic which supports the concepts of partial truth and linguistic variables (Zadeh, 1965). This is suitable for quantifying imprecise information and making decisions based on incomplete data (Kosko, 1993).

Mappings between gestural features and synthesis parameters are described by fuzzy rules with linguistic variables. An example

of a linguistic variable is the “intensity”, whilst its linguistic terms are “low”, “medium”, and “large”. Inputs in a fuzzy logic system are usually numeric, so it is necessary to convert these numeric values into linguistic terms. An input value can partially satisfy several linguistic variables at the same time. For example, if the feature has a value of 0.3, the “intensity” is somewhere between “low” and “medium”.

Fuzzy rules are specified in the form of IF-THEN statements:

IF $(x_1 \text{ IS } S_1) \text{ AND/OR } \dots, (x_n \text{ IS } S_n)$ THEN $y \text{ IS } T$

where x_i represents input fuzzy variables, y is the output variable, while S_n and T stand for input and output linguistic terms. The first step of applying the fuzzy model is to convert input variables into fuzzy logic variables. Then, output variables are calculated by evaluating the rules and the output values are converted to numeric form.

Fuzzy logic enables nonlinear many-to-many mappings between gestural features and synthesis parameters, while the rules based on linguistic variables can be easily understood and specified by composers. Because of these properties, systems based on fuzzy logic have been previously used in the musical domain for coding musical gestures (Orio and De Prio, 1998), analyzing the emotional expression in music performance (Friberg 2004), mapping between visual and aural information (Cádiz, 2006), sound synthesis (Miranda and Maia, 2005; Cádiz and Kendall 2005), and several other applications.

The fuzzy logic model specifies input and output variables, membership functions, fuzzification and defuzzification methods, and mapping rules for the expert system based on fuzzy logic. In our implementation, the fuzzy logic model can be specified using Fuzzy Control Language (FCL). This language is standardized by the International Electrotechnical Commission standard IEC 61131-7. The fuzzy rules have an intuitive IF-THEN form which allows musicians to modify and write new rules by themselves.

The fuzzy logic model used for this research accepts three features extracted from the raw data received from the mobile application. The fuzzy logic model has 5 outputs which represent values of sound synthesis parameters. All the membership functions used in the fuzzy model have a triangular form. To defuzzify output variables, the fuzzy logic model uses a technique based on the center of gravity which is the typical approach for models with real-valued output variables.

The rule set for calculating audio features consists of 30 rules which were manually written and adjusted after several iterations of subjective testing by the authors. Here are some examples of the rules:

IF frequency IS little THEN durationUpperLimit IS small;

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IF direction IS prominent THEN amplitudeVariation IS large;  
IF intensity IS moderate THEN amplitudeLimit IS moderate;
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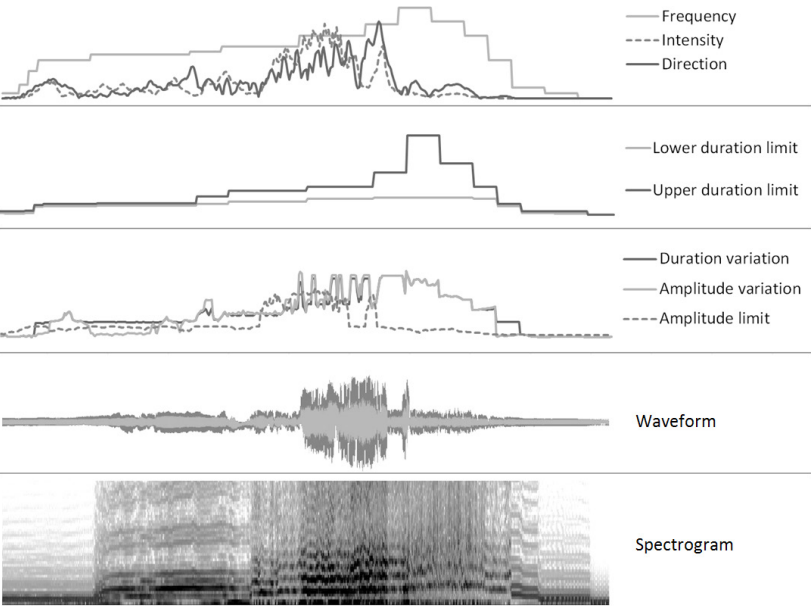
3.3 Implementation

The server-side was implemented using Pure Data, a visual programming environment for music and multimedia projects. The expert system based on fuzzy logic was implemented as a Pure Data external component which served as an interface between Pure Data and the jFuzzyLogic library (Cingalogani and Alcalá Fernández, 2012). Since jFuzzyLogic was written in Java, wrapper functions that rely on JNI calls have been implemented to serve as glue code between the main functions of the external written in C and the Java library.

4 Results

Experimentation with the system has shown that the intended mapping between physical gestures and the synthesis parameters has been achieved in accordance with initial requirements. Since we implemented a priori knowledge about synthesis parameters within the fuzzy model, physical gestures are also intuitively related to acoustical results. Stronger shaking causes more complex and louder sound, faster shaking produces higher average pitch with an increase in frequency drifts, while changes in the direction of shaking also affect the synthesized timbre. The overall impression of the sound is transparently and immediately related to physical gestures. Figure 3 shows data captured during

Fig 3. Data captured during a period of 11 seconds. The top chart shows features extracted from physical movements, while the second and the third charts show values of synthesis parameters produced by the expert system based on fuzzy logic. Pictured at the bottom are the waveform and the spectrogram of the resulting sound.



one experiment and proves the established relations between

selected features of the shaking movement, sound synthesis parameters, and the acoustical qualities of the synthesized sound.

The expressivity of this interface is satisfying. By combining different shaking intensities, frequencies, and directions, various timbral results can be achieved, from simple steady sounds to buzzy and noisy timbres which are characteristic of dynamic stochastic synthesis. However, mapping three movement features into five sound synthesis parameters meant deliberate and necessary limitations of the expressivity when compared to direct parameter control. Additionally, the selected features of shaking movements are not completely independent. For instance, it is difficult to increase the shaking intensity without increasing the shaking frequency. The consequence of such a dependency is that sounds with both low pitch and complex timbral texture cannot be easily achieved. However, the expressivity of the synthesized sound corresponds to the expressivity of the shaking movement, so we believe that users will not be able to notice those missing aspects of expressiveness, unless they have a lot of experience with dynamic stochastic synthesis and strict expectations before they start using the system.

5 Conclusions and Future Direction

As a solution for intuitive and immediate sound shaping at the micro-level, we proposed a system for mapping physical gestures into parameters of dynamic stochastic synthesis. The benefit of the proposed approach in comparison with direct parameter control is that it is straightforward and does not require deep understanding of the underlying sound synthesis model. This system is also convenient for live performances in which transparent mapping between movements and sound can be exploited in many ways. Unlike other similar systems for controlling synthesis parameters, this one is particularly focused on a non-standard synthesis method and therefore can be observed as an approach for shaping microsound using physical gestures.

From this point on, future research can continue in two different directions. The first one is achieving even closer connections between movements and the microsound by developing a new non-standard synthesis technique which would directly rely on nuances of physical movements instead on stochastic processes. Such a synthesis method would be interesting for dancers and choreographers who could explore the links between microstructures and acoustical features of synthesized sounds and dance movements.

The other research direction would be completely different. Instead of subordinating a synthesis model to the nature of

movement, the system for gesture detection could be extended to understand a much larger vocabulary of complex gestures. That way, gestures could be used as symbols and metaphors for triggering various modes of sound synthesis. As a result, higher expressivity could be achieved with interesting results in the context of dance-music intermodalities.

To conclude, the results of this research are generally encouraging with regards to our intention to develop a system for controlling the sound microstructure with physical movements. The proposed approach can be employed to control dynamic stochastic synthesis more easily and effectively, it can be used in live performances, and it can serve as a base for future research.

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Reflections on Live Coding Collaboration

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Keywords: live coding, algorave, jazz improv, collaboration

Reflections on a number of live coding collaborations with improvisors, choreographers and performance artists, drawing from informal discussion and audience feedback.

1 Introduction

Through my practice as a live coder of music, I have enjoyed varied collaborations with percussionists, live artists, performance artists, dancers and choreographers, as well as other live coders. In the following short paper I will reflect on a number of these collaborations, including with/within algorave, live Jazz improv, performance art and choreography practice. Some focus will be on the role of time and language, as core themes in live coding, but I will also consider wider cultural issues, and of the role of collaboration in making live coding meaningful. I conclude by considering how technology could better support close collaboration in the future. Throughout, informal reports by collaborators and audience members are drawn from, as well as reflections as a live coding performer.

2 Making collaboration visible: Inter- and intra-technology

When performing with technology on stage, there can be a lingering feeling that some aspect of the performance is invisible. Slub have projected screens since inception in the year 2000 (Collins et al. 2003), a habit which has been taken up by the live coding community at large (Ward et al. 2004). Slub consists of Adrian Ward, Dave Griffiths and myself in various combinations (Fig. 1 shows Griffiths and McLean), but our collaboration does not take place in our technology, but through the musical and sonic structures we produce. We do make a network on stage, but this is only to create a shared clock so that we may coordinate tempo changes, and share the same down beat. Our systems are otherwise decoupled, our collaboration being between our different

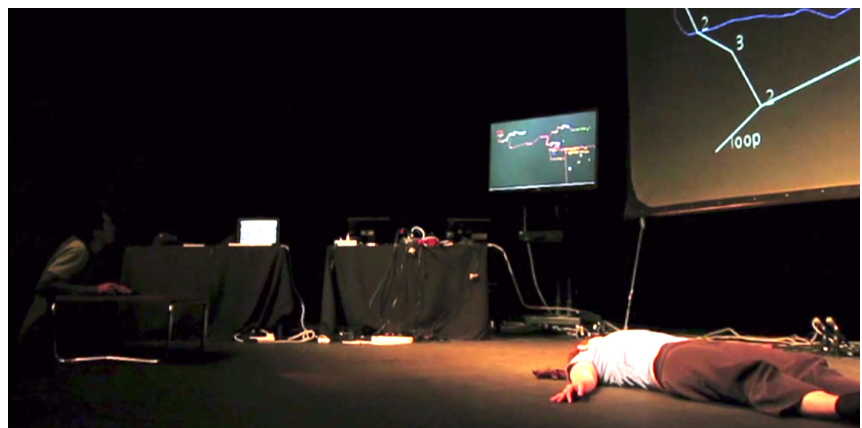
Fig. 1 Slub live coding at the Old Operating Theatre London, 14th January 2010. Photo: Evan Raskob



systems rather than through the same system. This is not clear to all audience members however, who through informal post-performance discussion have occasionally revealed an assumption that we are working on different parts of a technological machine, rather than working on our own machines and collaborating as musicians within a laptop ensemble.

While holding correct assumptions of the mechanics of a performance is not always important to an audience member's appreciation of a piece, there is one aspect which I consider critical; how the audience perceives balance between performers. I collaborate with instrumentalists and dancers as equals, as experienced improvisors with equal technical abilities over our instruments, languages and/or our bodies. The question is, how can such collaborations be staged to get their nature across, as balanced exchanges between two or more creative individuals? Reflecting the general role of computation in culture, an audience member's assumption might be that the laptop operator is somehow *controlling* the other performer, or at least processing their sound or movements in some way. Another assumption might be that the laptopist is carrying out mundane operations, while an instrumentalist or dancer is contributing the real creativity to the performance through 'authentic' gesture.

Fig. 2 Sound Choreographer <>
Body Code, Audio:Visual:Motion
Manchester, March 2013.
Photo: MIRIAD



Of course in many technology oriented performances, such assumptions as described above are actually true, and great imbalance between laptopist and a more 'physical' collaborator is not always seen as an important artistic consideration. However, the collaborations I have taken part in have always looked for balance. Kate Sicchio and I are developing a live code and live choreography performance as a confluence of our practices, setting up a feedback loop between choreography, the body, code, sound and back into choreography (see Fig. 2, and McLean and Sicchio 2014). We are ambivalent about the success of this piece, our experience as performers connecting our two notations has at times been very

good, but the physical strain placed on Kate on her side of the loop led one audience member to report feeling that I (as programmer) was torturing Kate (as dancer). In the piece, Kate's movements interfere with my code, but any torture felt by me is solely cognitive, and so less visible. Kate is herself a technologist as well as (and indeed as part of) being a choreographer, and has been instrumental in the recent conceptual development of live coding, but it can be difficult to get the nature of our collaboration, as an exchange between reflective technologists, across. Where we have agreed our performance has really worked, is where we have explained and discussed it first.

As an aside, this work carries a key problem when experimenting with collaborative performance; such performances are set up to fail; ideas collide and we learn from the pieces. All we can really do is embrace the risk, and hope that audience members perceive some of the possibility that we are reaching for, and often miss.

Fig. 3 Hession/McLean duo practice session, Leeds, 2014.
Photo: Paul Hession



Returning to the question of audience perception; how can collaboration through body and code be made more visible? One collaboration with live coder and drummer Matthew Yee-King as Canute¹ looks for ways of sharing data between an instrumentalist and live coder. Matthew produces probability distributions of hits on his drum kit, visualising them and sending them to me as Tidal patterns (McLean 2014), which I then transform through live coding with further visualisation. Six performances in, audience response has been increasingly positive in terms of encores and dancing, although perhaps more responding to the musical end result, and less on the conceptual basis of the work which is only visualised in the abstract.

A more directly interventionist approach has been found in collaboration with performance artist Susanne Palzer. Susanne curates a series of “OPEN_PLATFORM” happenings based on the idea of “Technology without Technology”, exploring notions of

¹ See <http://canute.lurk.org/> for information about and recordings of Canute.

Fig. 4 Binary Transmission, Palzer and McLean, Access Space Sheffield, 6th December 2013. Photo: Susanne Palzer

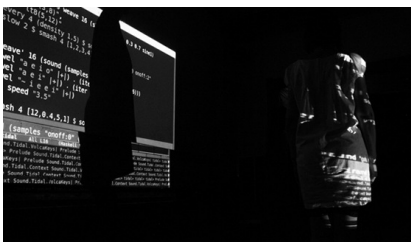


Fig. 5 On-Gaku, Palzer and McLean, Wharf Chambers, 25th January 2015. Photo: Rodrigo Velasco

digital art outside of the normal frame. She has developed a series of performance pieces where she steps on and off a (wooden) platform, sometimes with lights also switching on and off, exploring the digital in performance. We have collaborated on two performances so far, in the first “Binary Transmission” (Access Space Sheffield, 6th December 2013; Fig. 4), I knitted while Susanne stepped on and off and around her wooden platform, a knit for every on, and a pearl for every off. In this way her discrete, binary movements were transduced into the binary pattern of fabric. In our second collaboration “On-Gaku” (Bloc Studios Sheffield, 12th July 2014; Wharf Chambers Leeds, 25 January 2015, Fig. 5), I used a laptop rather than knitting needles, and did my usual live coding with Tidal. However, we hooked up a pressure sensor to Susanne’s platform, so that my screen was only projected while she stepped ‘on’. I worked using a wireless keyboard, and using the projection as my screen, so had to cope with only seeing the code I was editing for fleeting moments. In joining our individual practices in this way, our difficulty was more visible on both sides. In my case, I struggled to work as I could not see my screen for most of the time, and in Susanne’s, her physical exertion was clear.

It is perhaps telling that collaborations I am involved in often end up looking for ways of balancing difficulty and friction in interwoven performance practice, by deliberately introducing new difficulties and struggles. This works well within a performance art context. It is worth noting however that my musical collaborations with instrumentalists, including collaborations described in the following section, are far less troubled in terms of the nature of collaboration. When the collaboration is on the shared basis of sound, technology has less of a bridging role, and therefore has

less of an overbearing influence on audience reception of a piece. However, none of this is to say that our technology should in any way become invisible or seamless.

3 Percussion - generation at the speed of gesture, and freedom from the grid

A primary motivation for the development of Tidal over the years has been collaboration with percussionists. This began with a number of sessions and performances with drummer and digital artist Alex Garacotche in 2004, including the Ultrasound festival in Huddersfield. At the time I was using the feedback.pl editor for live coding with the Perl programming language, which included an interesting user interface application for self-modifying code. However, it was unwieldy, and when live coding “from scratch”, I might be a minute into a performance before I started making sound.

By switching to the Haskell programming language I have been able to develop Tidal as an embedded Domain Specific Language (eDSL), for composing pattern as higher order structures with highly economical syntax (McLean 2014). This allows me to respond to changes introduced by co-performers within seconds. As well as speed of reaction, it has also been important to develop an expressive approach to time. While 16 step dance music is a passion of mine, Tidal allows me to quickly express complex metric subdivisions, and layering time signatures on top of each other to create shifting polyrhythms. Tidal represents time using rational numbers, and patterns as functions rather than sequences, in a highly flexible manner.

Tidal is certainly not without its constraints, but the freedom which this representation of time offers me has allowed me to collaborate within free improvisation. My primary exploration in this area has been with drummer Paul Hession, who has honed his practice over decades, including through collaborations and more recently solo play. Paul has now extended his drum kit with a range of analogue, digital and physical techniques, and interestingly has explored collaborations with unsupervised ‘live algorithms’ alongside his occasional work with me as live coder (see Fig. 3, and Hession and McLean 2014). On reflection, these performances have centred on struggle with continual change.

My conclusion here is that while code necessarily distances the live coding musician from the physical production of sound, live coding technology, including my own, has succeeded in reducing latency between action and reaction close to the speed of gesture. This in turn has allowed myself as a live coder to collaborate closely with live instrumentalists, including in free jazz

situations. In this sense, live coding has genuinely brought programmers closer to the people around them.

4 Community growth and genre

Collaboration in music extends beyond co-performers, but also with audience members, and in the broad Musicking sense (Small 1998) where every activity around music culture is seen to be part of music-making. There is an argument that music has become formulaic and backward-looking over the past decade, lacking revolutions comparable to rock 'n roll and rave in the late 20th century (Fisher 2014). It is too early to say whether live coding will have real cultural resonance as an agent for change in mass media, but perhaps there is some potential shown in the media reaction to Algorave music (e.g. Cheshire 2013).

Algorithmic music has been present in dance music culture for some time, but Algorave has provided a new common ground for us to explore together (Collins and McLean 2014). Algorave is a collaboration without clearly defined edges, a space initially created by live coders such as Nick Collins, Dan Stowell, Matthew Yee-King and myself, and (I think crucially, in terms of establishing identity) graphic designer David Palmer. Creating this space has in some respects been janitorial, helping shape that identity in the background, while leaving space for organisers, performers and (perhaps most importantly) revellers to define what Algorave really means. What started as a joke of sorts has become unexpectedly successful - many people across the world (e.g. UK, Mexico, Australia, Germany, Peru, Belgium, Canada) have felt able to make Algoraves for their own, without asking anyone for permission. Some have been organised by practitioners and professional promoters, and quite a few within academic conferences, making an ad-hoc collaboration which spans research and practice.

5 Closer

I would argue that live coding is now proven as a reasonable means to make music, both within small engaged live coding communities, and within larger enthusiastic, dancing audiences in the hundreds. Perhaps the next leap is to see how live coding can bring us closer together, and unearth modes of interaction that could take us further away from software engineering, towards closer shared experience of code. From the perspective of music technology, the most recent leaps in shared programming environments are a decade old; the *Republic* live coding environment for SuperCollider (Rohrhuber et al. 2007), and the *Reactable* tabletop instrument (Jordà et al. 2005). The former explores conversational,

shared live coding style, and the latter simultaneous editing of a sonic dataflow network by collaborators around a circular table.

My feeling is that a further leap is overdue, and the results could take live coding further away from the well established applications for programming languages, into radically different ones. In particular, environments aimed at creative, shared exploration through abstraction, and at shared experience rather than end results.

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Digital Symbiosis: The Aesthetics and Creation of Stimulus-Reactive Jewellery with Smart Materials and Microelectronics

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Keywords: Smart Materials, CAD, Posthuman, Microelectronics, Jewellery, Thermochromic, Arduino

This article explores how smart materials, and in particular thermochromic silicone, can be integrated into a wearable object in combination with microelectronics to create aesthetically coherent stimulus-reactive jewellery. The different types and properties of thermochromics are discussed, including experiments with layering pigments that react at different temperatures within three dimensional silicone shapes. The concept of creating digital enchantment through playful interaction is introduced, illustrating how accessible microelectronics can be used to facilitate the creation of responsive jewellery objects. Bringing together digital methods of fabrication with craft methodologies to create objects that respond intimately to changes in the body of the wearer and the environment is presented as an outcome of this research project. Moving towards the notion of a posthuman body, potential practical applications for these jewellery objects exist in the areas of human-computer interaction, transplant technology, identity management and artificial body modification, where such symbiotic jewellery organisms could be used to develop visually engaging, multifunctional enhancements.

1 Introduction

The idea of creating a jewellery organism that comes alive on the body has fascinated and inspired my research ever since learning about the potential of smart materials to generate vitality in static objects almost twelve years ago (Saburi 1998). While smart materials have been known to scientists for far longer, and have been used to great effect in engineering and aeronautic applications as actuators, their use in contemporary art and craft has been sporadic, most likely because of the challenges posed in processing and shaping them. With the increased prevalence of digital technologies in our everyday lives, the questions posed to the contemporary craft practitioner regarding the creation of a more refined interaction between the digitally enhanced object and its wearer have become progressively more prominent in the applied arts (Wallace 2007). Through examining the notion that human biology is a part of material culture, where the body can be shaped, customised or altered through surgical intervention and scientific innovation, my research explores how recent developments in material science and wearable technologies can be viewed as moving towards a future embracing the posthuman body, bridging the gap between craft practitioner and scientific discovery (Hayles 1999). Developing a holistic approach-whereby material experimentation and digital production processes are used to facilitate the development of aesthetically and biologically integrated wearable technologies, is the goal my research moves towards. More immediately-however, I am challenging the perception of smart materials and their application within the field of contemporary jewellery-in both an artistic and scientific context-through proposing the development of symbiotic stimulus-reactive jewellery organisms.

Taking David Rose's concept of the enchanted object (Rose 2014) and playful interactions as a starting point, my research addresses aesthetic considerations alongside functionality, thus developing material and technological solutions that constitute an integrated and functional yet unified part of the jewellery object as a whole. While previous projects have placed a strong emphasis on simply creating receptacles to accommodate electronic components within a wearable object, the possibilities offered by digital manufacturing technologies such as rapid-prototyping and computer aided design (CAD) have expanded the aesthetic vocabulary available to the practitioner. Furthermore, the development and increasing availability of a range of stimulus-reactive smart materials, in addition to the progressive miniaturisation of electromechanical components, has turned the prospect of developing jewellery objects that appear to be responsive

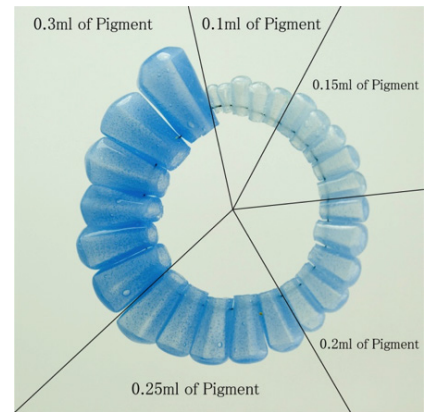
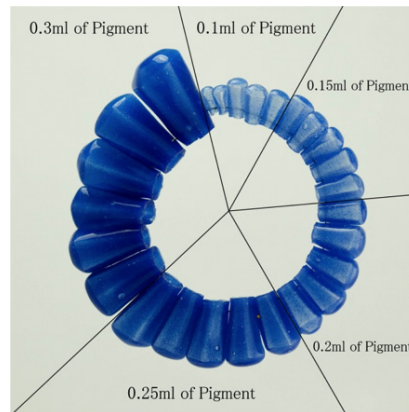
to their environment, yet depend closely on an interaction with the physiology of the wearer's body to stimulate these responses, from a distant imagining into a feasible goal.

2 Exploring the Future – Smart Materials

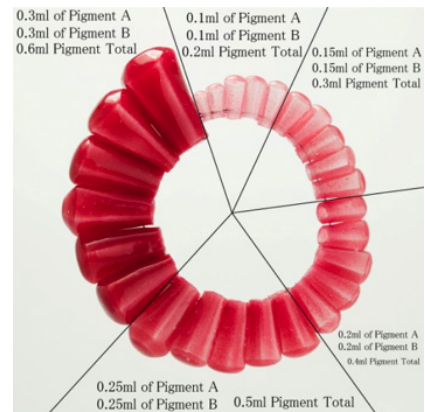
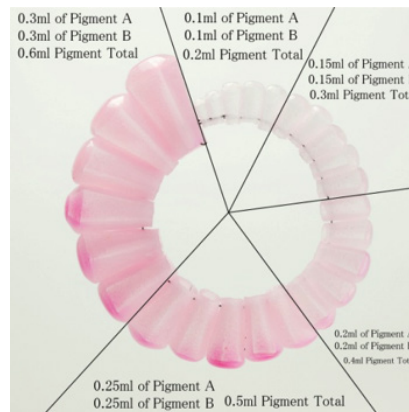
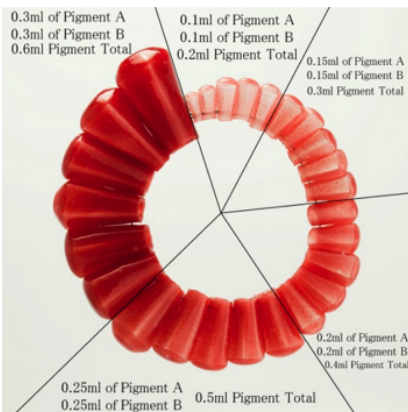
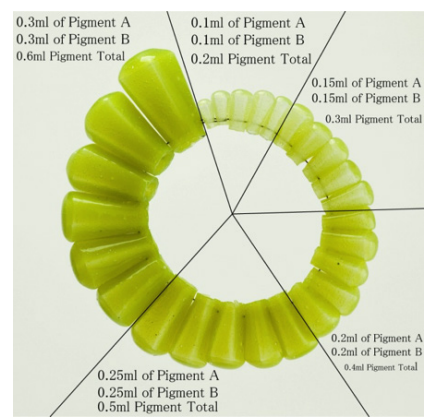
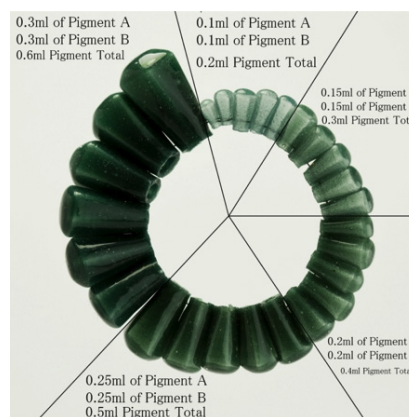
I initially became aware of a group of smart materials known as Thermochromics through a presentation given by Dr. Sara Robertson at the CIMTEC 2012 conference in Montecatini Terme, Italy, exploring the potential of temperature-sensitive thermochromic dyes and heat-profiling circuits in textile design (Robertson 2011). Intrigued by their ability as a smart material to respond directly to a change in body temperature through colour change, I began to explore their potential in combination with the three dimensional silicone shapes I had been developing. Thermochromics are commonly available as either dye slurry or in powdered pigment form, and fall into the two main categories of leuco or liquid crystal thermochromics. Either variety is available in a range of colours and with different temperature change points, displaying a visible colour change with an increase or decrease in exposure temperature. Leuco dyes change from pigmented to colourless when a heat or cold source is applied, depending on their change temperature, and assume pigmentation again as soon as the source of temperature change is removed. Analogue Liquid Crystal dyes cycle through a set of colours that correspond to the temperature they are exposed to, with the most recognisable form being the 'peacock' colour pallet ranging from red through yellow, green and deepening shades of blue. After a certain peak temperature is reached towards the dark blue spectrum, usually about 20 degrees above activation temperature, visibility of the pigment ceases and only returns in the cooling phase when it cycles through the previous colour shifts in reverse until it once more falls below its activation temperature. Digital Liquid Crystal technology, in which the pigment appears to be either in an 'on' or an 'off' state according to the temperature it is exposed to, has also recently become available. The colour change reactions of thermochromic dye systems are available as reversible and irreversible types. However, as one of the definitive conditions of smart materials is full reversibility, only the former type can be categorised as such and is of interest to me in this respect.

There are a variety of practical and industrial applications for thermochromic pigments, dyes and paints. One of the most well known is the inclusion of liquid crystal technology in forehead thermometers, where each degree of measured body temperature is assigned a corresponding colour. Similarly, Leuco dyes are widely used in fuel assemblies, to test combustion engines and as

Figs. 1 & 2 Example of a Single Pigment Test: Blue 27°C in its unchanged and changed state



Figs. 3 & 4 Example of a Dual Pigment Test: Blue 27°C and Yellow 38°C in its unchanged and changed state



Figs. 5, 6 & 7 Example of the progressive stages of change in a dual pigment sample of Magenta 41°C and Yellow 38°C

friction markers in engineering, effecting an irreversible colour change when heated and thus signalling a state change of the monitored component (Robertson 2011). My research currently focuses on exploring the potential of layering leuco and liquid crystal pigments in silicone to explore the interplay of colours created by different colour and temperature combinations. I have adopted a rigorous testing protocol for these experiments, starting with four base pigments in different colours and each with a different change temperature (Blue 27°C, Yellow 38°C, Magenta 41°C, and Red 47°C). Each batch of samples is made using the same process, requiring 16.5g of mixed silicone for a full set of 25 with

one extra shape as a spare. An initial set of shapes of each single colour was prepared, starting with 0.1 ml of pigment and adding 0.05 ml of pigment per every five shapes (Figs. 1. & 2.).

Next, two pigments were combined in a single mix, starting with 0.1ml of each colour (a total of 0.2 ml) and adding 0.05 ml of each colour (a total of 0.1 ml) per every five shapes. The resulting colours were then evaluated for hue, transparency and strength of pigmentation in both their changed and unchanged states. In their unchanged state, pigmentation strength is greatest in the final segment of each colour, with saturation levels nearing opacity, and weakest in the first segment, creating a translucent finish. Translucence yields to opacity at around 0.3 ml of added pigment. This result was predicted and corresponds to expectations formed from my past research in combining artists' pigment with silicone. The resulting colours of the combination samples follow the general rules for colour mixing as demonstrated on a colour wheel, and the resulting hues range from slightly disappointing to very pleasing although this is arguably a matter of taste and artistic intent. With the application of heat, the samples go through a variety of colour changes. In their first changed state, the lower temperature colour fades and reveals the underlying higher temperature pigment. The samples appear as a lighter version of their unchanged colour at this stage, with some combinations such as blue and yellow displaying a very distinctive change, others such as magenta and yellow displaying a more subtle outcome (Figs. 3. & 4.). If heated again the second pigment fades and reveals a milky base colour with the dominant pigment in evidence as a pastel shade (Figs. 5-7.). It is possible to further modify the colour response by introducing a permanent base shade consisting of artist or special effects pigments to the mixture, and I am currently conducting tests to exploit the aesthetic possibilities inherent in this suggestion. Two pieces in which this idea is explored are the *Xylaria* Brooch (Fig. 8.) and the *Cocoon* Necklace

Fig. 8 *Xylaria* Brooch in its changed state, Katharina Vones (2013)

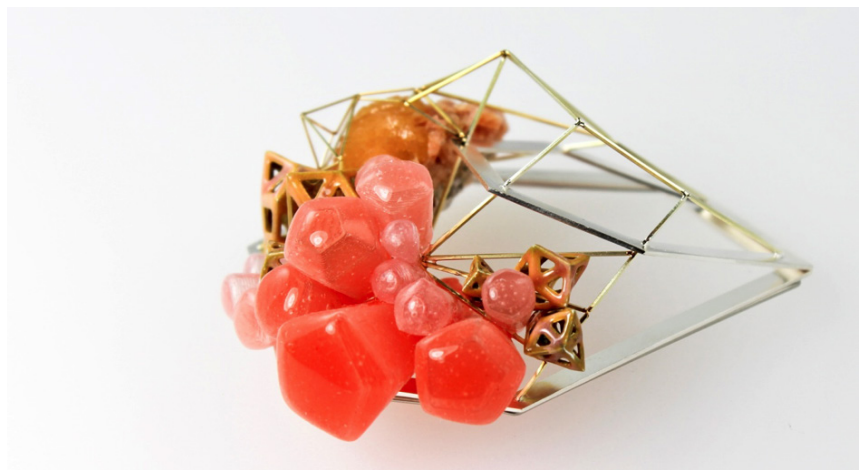


Fig. 9 *Cocoon Necklace* in its changed state, Katharina Vones (2013)



(Fig. 9.). Both feature thermochromic silicone shapes which react to environmental temperature changes but also contain a stable base pigment which becomes visible once the thermochromic pigment fades. Thus the *Xylaria Brooch* changes from raspberry pink to bright orange, whereas the *Cocoon Necklace* contains shapes that appear violet and then fade to light blue. The latter also has black 3D-printed components that have been treated with liquid crystal technology and change through a peacock spectrum of hues of green and blue from about 27°C.

3 Digital Enchantment

While the exploration and use of smart materials constitutes one area of my research, another equally important aspect is the creation of an elusive characteristic defined by the term digital enchantment (Rose 2014). Within the context of wearable futures, this could best be described as the sensation of wonder and surprise created by an unexpected, captivating and apparently spontaneous reaction between the object, its user, discreetly embedded technology and its environment. It stands in direct opposition to recent developments to commercialise the wearable futures market by focusing on miniaturising and adapting already existing technologies to be worn on the body. Examples of this include a number of smart watches such as the *Samsung Gear* and the *Apple Watch*, as well as the much talked about *Google Glass*. However, these devices have so far failed to capture the imagination of users, with the *Samsung Gear* reportedly suffering from poor sales (Amadeo, 2013) and *Google Glass* having recently been removed from the consumer market altogether in order to be developed solely for institutional and business use (Hedgecock 2015). Whilst sporting a multitude of arguably useful functions such as cameras and internet access, these wearable devices are

very much rooted in the semiotics of traditional gadget culture, introduced through popular culture icons such as James Bond and Dick Tracy as early as the 1930s (Johnson 2011). Instead of discovering new ways to engage the wearer through playful interaction, this recent incarnation of wearable devices has maintained an aesthetic and modes of usage firmly rooted within established parameters by simply imbuing familiar types of body adornment with novel technological content. My research addresses these issues through exploring the ways in which an object worn on the body is imbued with digital enchantment through encouraging playful interaction with changes in the environment and biological impulses of the wearer.

3.1 Arduino – Accessible Electronics

The *Arduino* system of microelectronic components offers an accessible starting point for those less experienced at assembling electronic components and programming (Margolis 2011). As the boundaries between digital art, craft and technology become more blurred, the need for craft practitioners to become fully versed in the vernacular of the digital becomes more pressing. Embedding electronics within wearable objects poses its own set of challenges, in particular that of miniaturisation and power supply. While the latter is at the present time dependent upon technological developments that would exceed the scope of my research project, the former is an issue that successive generations of ever smaller components, such as the recent *Adafruit Gemma*, *Flora* and *Trinket* microcontrollers, have begun to address (Fried 2014). In order to imbue the wearable objects I am creating with a sense of being ‘alive’ I initially started experimenting with a variety of LED components that respond in some way to their environment.

Fig. 10 *Arduino Uno* RGB LED Colour Organ, Katharina Vones (2012)

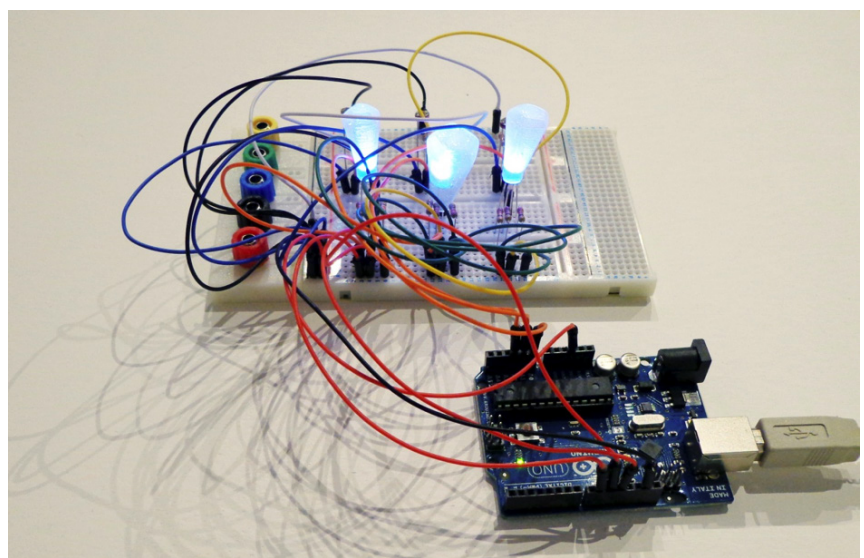


Fig. 11 *Geotronic Brooch*, Katharina Vones (2013)



Fig. 12 *Hyperhive Pendant* (2 of 3), Katharina Vones (2014)



The first such circuit I created is a light sensitive colour organ (Fig.10.). Using an *Arduino Uno* microcontroller board, three RGB LEDs and three miniature photocells, the light sensitive colour organ responds to changes in light levels to each of its three photocells by sending a corresponding colour value to the RGB LEDs and changing the colour accordingly. By sensing different light levels and expressing them through changing colours, the jewellery object reacts to environmental circumstances as a photosynthetic organism might. After testing on a breadboard, the circuit is then recreated with an *Arduino Pro Mini* microcontroller board to miniaturise the assembly for integration into a wearable jewellery object. As a development of the idea of creating an interactive synergy between wearer and object through the use of light, the *Geotronic Brooch* (Fig.11.) incorporates a programmable RGB LED that simulates the rhythm of a beating heart through its pulsations. Further advances towards creating synergetic jewellery objects are evident in the *Hyperhive* series of stimulus-reactive pendants (Fig.12.). Sensors that measure the heart rate, proximity and touch of the wearer are integrated into 3D printed pendants

and react to intimate contact by changing colour, lighting up or generating movement in combination with thermochromic silicone, this could generate a very dynamic and playful interaction between the object, its wearer and the environment.

3.2 Thermochromic Silicone and the Wearable Object

To fully exploit the colour responsiveness of thermochromic silicone without having to rely on a spontaneous reaction to changes in environmental temperature, it is necessary to incorporate a heat generating circuit into the wearable jewellery object which in turn is activated by a sensor/microcontroller assembly. While the use of heat sinks cut from thin copper foil or woven from conductive thread has been well established in the works of digital textiles artists Maggie Orth (Orth 2007), Sara Robertson (Robertson 2011) and Lynsey Calder (Calder 2014), these approaches are less suitable for use within thermochromic silicone, primarily because of its low shore hardness and inherent high flexibility, making the integration of such circuits at the manufacturing stage precarious. An additional complication arises from incorporating effectively uninsulated conductive materials into a jewellery object made from precious metals such as silver or gold, that are highly conductive in themselves and could cause short circuits if accidental contact between the heating element and components of the object was established. As a viable alternative, a ceramic Peltier element can be used. Based on the principle of the Peltier Effect of heat displacement through electric current, Peltier elements rapidly heat on one side while equally rapidly cooling on the reverse. This makes them very suitable for use in wearable technologies, where a current driven, predictable and directional heat source is often desirable, particularly where the element might come into contact with the wearer. While copper heat sinks can radiate heat on both sides of the circuit and thus need to be fully embedded to protect the wearer, the cool side of the Peltier element remains safe to handle, while generating enough heat to trigger the thermochromic reaction on the reverse. Temperature can be controlled by current supplied to the element, making it possible to effect subtle colour changes in the silicone shapes. One slight disadvantage is the relatively slow cycle of the Peltier element once current is removed, making rapid successive colour changes impossible.

4 Conclusion – Towards a Posthuman Future

Jewellery and the concept of adorning the body have a rich and well-documented history of being imbued with meaning that stretches beyond notions of wealth, value, social status, aesthetics and consumerist desire into the realms of emotional and conceptual significance (Skinner 2013). Digital jewellery practitioners such as Sarah Kettley (Kettley, 2007) and Jayne Wallace (Wallace, 2007) through their body of work have explored ways in which technological developments can be used in a jewellery context to forge and enhance emotional connections through stimulating a meaningful interaction between the jewellery object and its wearer. Other practitioners such as Norman Cherry (Cherry, 2006) have gone further by suggesting that eventually the boundaries between ornament and body will become indistinguishably blurred through extreme modifications and implantable jewellery, a development that radical jeweller Peter Skubic had already foreshadowed in 1975 with his performance *Jewellery Under the Skin* (den Besten, 2013). The development of the 'Carnal Art' manifesto by French artist Orlan as part of her project *The Reincarnation of Saint-Orlan* from 1990 onwards, in which the artist's body serves as the site of repeated surgical interventions and modifications, can be seen as a logical trajectory of this line of enquiry, albeit sited within the discourse of feminist performance art (Hirschhorn, 1996). Against this backdrop of ongoing exploration, the development and expansion of the concept of the Posthuman body to question the role technology and body modification could play in shaping the physical realities of the future, both on a functional and aesthetic level, has gained increasing momentum (Hayles, 1999).

Having developed a range of stimulus-responsive jewellery objects using smart materials and microelectronics, the question remains how these wearable futures could be integrated even more comprehensively into the body of the wearer. At present still recognisably autonomous objects, current advances in transplant technology and the ability to use human cells as a material in 3D printing offer tantalising glimpses of a future where the body could become host to near-organic, possibly artificially intelligent jewellery organisms. Moving towards a future in which technology could become permanently integrated into the complex systems of the Posthuman body I am intrigued by the possibilities and challenges facing the contemporary jeweller in advancing the debate surrounding the Posthuman and interactive adornment.

Potential practical applications for this line of investigation exist in the areas of human–computer interaction, transplant technology, medically assistive objects, identity management and artificial body modification including prosthetics, where such

symbiotic jewellery organisms could be used to develop visually engaging yet multifunctional enhancements of the body. The intersection between technological refinement, the exploration of smart materials and new manufacturing technologies as well as the development of an aesthetic expression that supersedes ideas of mere gadgetry is a challenge in this area of research and one which I am in the process of addressing with my contribution to the field.

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Sonically Tangible Objects

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Keywords: Presence, Tangibility, Augmented Reality, Virtuality, Perception, Interaction, Haptics, Sound, Touch, Binaural Audio, Tactile Stimuli, Gesture Control, Haptic Interfaces, Sound Interfaces

A unique power of virtual objects is that they do not have to look, feel or behave like real objects. With this in mind, we have developed a virtual cube that is part of our real, physical environment but, unlike real objects, is invisible and non-tactile. ‘Touching’ this virtual object triggers binaural sounds that appear to originate from the exact spot where it is touched. Our initial experimentation suggests that this sound-based approach can convey the presence of virtual objects in real space and result in almost-tactile experiences. In this paper, we discuss the concept behind, implementation of and our experience with the sonically tangible cube and place our research in the context of tangible interaction, perception and augmented reality.

1 Introduction

With the advent of augmented reality (AR), the virtual has become part of our environment in a profoundly new way. Virtual objects are no longer confined to virtual spaces, digital devices and displays. Rather, virtual objects can appear in and inhabit our real, physical space and act as if they were actually present in our otherwise real environment.

Much research in augmented reality focuses on making virtual objects as real as possible. Researchers and developers strive for photorealism and aim for scenarios where virtual objects cause the same occlusions and shadows as physical objects (see, e.g., Gibson and Chalmers 2003). Similarly, scientists include physics simulations to make virtual objects adhere to physical laws and move like real objects (e.g., Kim, Kim, and Lee 2011). In line with this, there is a focus on tangible interfaces and techniques that allow users to interact with virtual content in the same way as they would with real physical objects (e.g. Billinghurst, Kato, and Poupyrev 2008; Buchmann et al. 2004).

Our research follows another direction. Instead of imitating reality, facilitating physical interaction or simulating real-world properties, we want to create new experiences that have no equivalent in a purely physical world. We are interested in how augmented reality scenarios can differ from strictly physical, ‘unaugmented’ environments.

In this project, we explore a new, non-visual way of conveying the presence of virtual objects in real space. Presence is often associated with the experience of ‘being present in a virtual environment’. However, we believe that another form of presence, namely in the sense of ‘something virtual being present in our real environment’, is key to augmented reality experiences. With this project, we explore whether the presence of virtual objects can be experienced through a combination of touch gestures and spatial sound.

The project presented in this paper is motivated by two underlying considerations. Firstly, virtual objects do not have to look or behave like real objects in order to be a believable part of our real, physical space (cf. Schraffenberger and Heide 2013a). Secondly, virtual objects could potentially be perceived differently from how real objects are perceived.

Inspired by this, we have developed a new kind of virtual object – the so-called sonically tangible cube. Unlike real objects, this cube is invisible and it does not provide tactile feedback. However, ‘touching’ the virtual cube triggers binaural sounds that appear to originate from the exact spot where it is touched. Our initial experiments show that through this sonic feedback,

virtual objects can gain an almost-tactile quality and appear as if they were actually present in real space. It is this idea of making virtual objects both tangible and present through spatial sonic feedback that distinguishes “sonically tangible objects”.

Several questions have fuelled the development of the virtual cube and our research into sonically tangible objects. First and foremost we were wondering if it is possible to leave out the tactile component in tangible interaction. If there is no tactile stimulation, would the virtual object still be perceived as part of real space – and if so, would it be experienced as an object with a tactile, physical component? We were intrigued by how it could feel to touch an object that provides no tactile sensations. Furthermore, we were eager to learn more about how virtual objects can differ from real objects.

While we provide preliminary answers to these questions, the focus of this paper is on the underlying concept of sonically tangible objects. (So far, inferences regarding the perceptual qualities of the cube are based on informal testing and on our subjective experience with the cube).

The central idea – that the cube is tangible but not tactile – calls for a distinction between the terms tangible and tactile. In this paper, things are called tangible, if they can be perceived by touching or being in contact with them. Only objects that also stimulate the tactile receptors (as found in the skin and tissue) are referred to as tactile. This understanding leaves room for objects that are tangible but not tactile.

The paper consists of 4 sections. In the following section (2), we share choices made and insights gained during the development of the project, describe the setup and implementation of the sonically tangible cube and discuss our experience with it. Following this (3), we compare the project with related work and place it in the context of pertinent research fields, such as perception research, augmented reality and tangible interaction. The paper ends (4) with a reflection on the project and possible directions for future research.

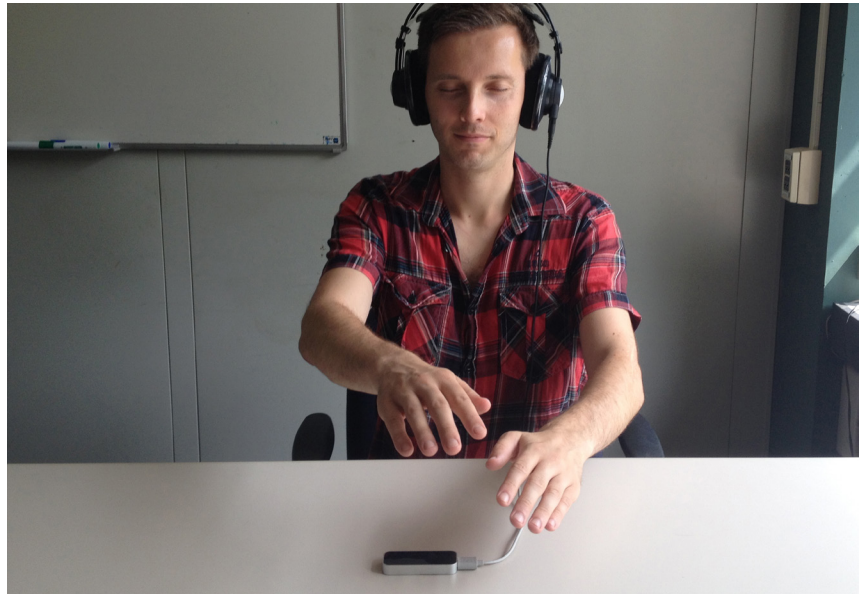
2 The Sonically Tangible Cube

The sonically tangible cube is a virtual object. It is unlike any real object in the sense that it is non-tactile, invisible and lacks physical properties, such as weight and temperature. It does, however, have sonic and spatial properties such as a shape, texture and loudness. Although the cube has no tactile component, its presence can be perceived through touch. When fingers enter the cube, sound appears to originate from where the virtual object is touched. The resulting sonic feedback not only corresponds to

the fingers' positions but also fits the movement of the fingers. Fast finger movements result in more agitated soundscapes while slower movement causes less dense, more distinct feedback. As the cube is non-solid, fingers can move through it and explore its inner texture.

2.1 Implementation and Setup

Fig. 1 A colleague explores the virtual, invisible and non-tactile cube. A Leap Motion Controller is used to track the position of his fingertips.



The virtual cube is 20 cm x 20 cm x 20 cm of size and it floats 10 cm above the work desk of one of the authors. The technical setup consists of a Leap Motion Controller (www.leapmotion.com), which detects the position of the participant's fingertips in real space. It is placed on the desk and senses hand movement above the device (see Figure 1). A custom *Max* (2014) patch, which runs on an Apple Mac mini, interprets the data provided by the Leap Motion. Interfacing with the Leap Motion device is realized with a Max external object 'aka.leapmotion' by Akamatsu (2014). In our current setup, the frame rate of the Leap Motion device is around 57 fps when the office is naturally lighted and slightly above 200 fps when the amount of interfering infrared light is reduced by darkening the room. The Max patch evaluates whether and where the participant is touching the cube on the basis of the fingers' coordinates. If the fingers are located within the 20 cm x 20 cm x 20 cm area that has been defined as the cube, their movement triggers pre-recorded binaural sounds. This interpretation of the finger position works for every finger independently and allows the participant to explore the cube with up to ten fingers at a time.

Constraints of the current setup are that the sound only matches the fingers' position if the participant is sitting at the right spot and directly facing the cube. Also, due to the frame rate

of the Leap Motion device, very fast hand-movement can cause a mismatch between the hand-position and the spatial information of the triggered sound. Moreover, finger movement is sensed best, if the hands are held horizontally.

2.2 Development

The sonically tangible cube was developed in an iterative process during the course of several months. In the course of the project, the authors acted as researchers, developers and participants. Additionally, colleagues were asked to provide feedback and describe their experience with the cube on occasion.

From the beginning, we have explored the idea of making virtual objects *tangible* and *present* through sonic feedback. The topic of (in)visibility was left aside for future research and hence, many evaluations have been conducted with closed eyes. Two determining observations and decisions were made concurrently in the early stages of the development process.

Shape

One of the two early decisions regards the shape of the object. We have started out with several simple geometric shapes and figures such as lines and planes and cubes. Our initial experimentation indicated that it is very difficult to experience a plane or a line. Running one's hands freely through a three dimensional object and exploring its borders and inner texture offered the most intriguing, tactile-like experience and promised to convey an object's presence best. Hence we have decided to focus on a cube-shaped virtual object.

Binaural Audio

The other decisive observation concerns the sonic aspect of the project. In the beginning, simple synthesized clicks were played back in mono (feeding the identical signal to both the left and the right channel) through closed Beyerdynamics DT 770 Pro headphones whenever a virtual object was touched. This was done in order to learn about the effects of linking movement in a certain area to a basic sonic response. However, our initial trials showed that the resulting experience was closer to being informed that one's hand had entered a predefined space rather than a direct sensory experience of an object in space. This did not come as a complete surprise. After all, interacting with real objects and materials – crumbling paper, scratching on a surface, typing on a keyboard or moving the mouse – causes sounds that originate

from the objects themselves and from the position where they are touched rather than spatially uncoupled mono signals.

This is where the idea of using binaural audio in order to make the sounds originate at the fingertips came into play. Binaural audio is based on the notion that hearing makes use of two signals: the sound pressure at each eardrum (Møller 1992). If these two signals are recorded in the ears of a listener, the complete auditive experience – including the three dimensional spatial information of the sounds – can be reproduced by playing the signals back at the ears.

In order to investigate the potential of binaural recordings, we conducted some simple initial experiments. For example, we recorded the sound of someone knocking on the closed office door and the sound of the ringing phone while working in the office. From these initial experiments it became clear that binaural audio indeed can convey the desired experience. When listening back to those recordings later on, the sounds seemed to originate from those exact spots where they originally had happened. The virtual ringing of the phone was practically indistinguishable from a real call. The simple knocking sound was powerful enough to create the illusion of ‘someone actually being behind the door’, and hence proved capable to communicate the presence of something or someone in real space. The use of binaural recordings has since grown into a key aspect of the project.

The move to binaural audio went hand in hand with a switch to open AKG K702 headphones. Due to the open nature of the headphones, the recorded sounds mix in with the sounds naturally present in the environment. This additionally supports the experience that the virtual sonic object inhabits our real physical space rather than a virtual or separate space.

Recordings

What should the virtual sonic object sound like? The choice of using binaural recordings introduced the question of what to record. We were searching for sounds that (1) are abstract (do not invoke the idea of a specific real object), (2) have a tactile quality and (3) support the idea of a non-solid object/material that allows the fingers to move through it. Several different sound sources have been tested during the development: for example, foils, paper, plastics, packaging materials from everyday objects, rattles and empty bottles. All sounds were produced by interacting with the materials with the hands and fingers. This choice was based on the assumption that sounds that actually are created by hand/finger movement are more likely to fit the exploratory hand gestures of the participant and more likely to create a tactile-like

experience. (In the same sense as the sound of squeaking nails on a chalkboard can be an almost-tactile, physical experience, even if someone else is scratching the board). For the current implementation of the sonically tangible cube, we have settled on the sound of aluminum foil, produced by squashing a tiny plastic bag filled with small crumbles of the foil.

To make the sounds appear as if they originate from the position where the cube is touched, a custom set of binaural recordings has been prepared. For this, we have divided the cube into 64 sub-cubes of 5 cm x 5 cm x 5 cm (see Figure 2). Five-second samples of aluminum foil sounds were recorded at all 64 positions within the cube. For this, we used a ZOOM H4 audio interface and two DPA 4060 microphones. The microphones were placed slightly above the ear-entrance of one of the authors and the sound was recorded with a basic Max patch. For the recordings, the author successively produced the desired sound by squashing the little plastic bag and rubbing the aluminum crumbles against each other at each of the 64 subareas. Aside from this, the author was sitting motionlessly in front of the desk, facing the cube just like participants do during the experience (see Figure 1).

Sound Design and Mapping

When a participant interacts with the cube, the positions of his/her fingers determine which of the 64 recorded audio samples are played back. If a finger is placed in a sub-cube, the corresponding recording is activated. However, first tests showed that simply playing back the recordings resulted in a sound that only matched the fingers' positions, but not the different variations in hand and finger movement (slow, fast, no movement, etc.). Hence, we have experimented with more complex settings that map the movement of the fingers to parameters in the sound design.

Our current implementation knows two sound design settings. Both react to each finger individually. The first setting makes use of granular synthesis. Here, the change of a finger's position triggers the playback of an audio grain that is taken from the binaural recordings. Each grain is between 10 ms and 20 ms long and is varied slightly in pitch/playback speed.¹ Furthermore, a random offset is used to vary the position in the binaural recording from where the grain is taken. This causes every grain to sound differently, which is crucial for the believability of the experience.

The second setting follows a similar underlying idea. Here, the binaural recordings are layered and looped. A faster movement activates more layers. Each active layer loops the five-second recording, starting at a random position within the sample and playing it back with a slight variation of speed/pitch.¹

¹ The changes in playback speed also influence the spatial characteristics of the sounds. However, as those variations were minimal this effect was negligible.

Both settings result in a louder, more complex and dense soundscape if the finger moves fast and in a softer, less dense but more distinct soundscape if the movement is slow. As this happens for each finger individually, the amount of fingers used by the participant has a similar effect: The more fingers are involved in the exploration, the denser the sound. The two settings differ with respect to textural nature of the sound. Whereas the granular synthesis results in a more gritty and rough soundscape, the layered loops produce a thinner, airier sound texture.

For either setting, movement is necessary to ‘excite’ the virtual cube and to elicit sounds. No movement results in silence, even if the hand is placed in the cube. However, as it is impossible to keep one’s fingers completely still, occasional slight tremble of the digits will cause corresponding sound output.

2.3 Experiencing the Cube

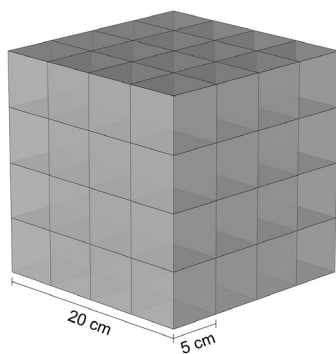


Fig. 2 The sonically tangible cube was divided into 64 sub-cubes. A binaural recording was made at all 64 positions. Image of the cube contributed by Wim van Eck.

How does the cube feel – does the experience really differ from simply moving one’s hands through thin air? Do we perceive the cube as present in space, do we perceive it as tangible? It is important to systematically investigate this by performing experiments with a group of unbiased participants in the future. In the following, we discuss our own experience with the sonically tangible object and compare it to known experience.

On one level, the experience can be compared to moving one’s hand through a beam of light. We can clearly see the beam’s presence in space, but we cannot feel it. Similarly, in the case of the cube, there is no traditional tactile feedback but our ears still tell us that something is there.

On another level, experiencing the cube better compares to feeling out a physical object blindly with one’s hands. After all, it is only through the physical act of touching that we can perceive the cube in the first place. There is no notion of the object, unless one is in contact with it. Also, like in typical haptic perception, the experience of the object takes time and happens through exploratory gestures with one’s fingers. Furthermore it is similar to touching a real object in the sense that this, too, can cause sounds at the corresponding position.

Yet, the experience is also inherently different from interacting with a physical object. One can, for example, not hold, move and turn the object. Instead, it is possible to move right through the cube and explore its inner texture and structure. Also, it is impossible to simply follow the contour of a sonically tangible object and to explore its shape that way (cf. Lederman and Klatzky 1987). Rather, the contour can be perceived by repeatedly crossing (zigzagging around) the boarder of the object and

moving in between the sonic space of the cube and the silent space surrounding it.

Last but not least, interacting with the cube has similarities with playing gesture controlled open-air instruments such as the Theremin. (The Theremin is played by moving one's hands in the space between two antennas.) Also here, movement in space results in sonic output that corresponds to the position of the hands.

While it remains difficult to put the experience of the cube in words, one thing seems clear: Touching the cube is different from simply moving one's hands through thin air. When we move our hands through air, we feel nothing but empty space. The cube, in contrast, inhabits the space. While empty space simply is experienced as empty, the cube is experienced as something that is present and that can be touched. Although the experience is not tactile in the traditional sense, it definitely has tactile-like aspects.

3 The Cube in Context

Our project is multi-disciplinary; it draws from and contributes to various fields of research, such as augmented reality, tangible interaction and perception. In this section, we take a second look at the cube and discuss the virtual sonic object in the light of related research.

3.1 Tangibility and Presence

The cube deals with (in)tangibility, requires active bodily engagement and it explores the possibilities of a tangible experience without tactile stimuli. As such, our research relates to the field of tangible and embodied interaction. Furthermore, the cube is concerned with the presence of virtual objects in real space, and hence relates to the field of augmented reality. Tangibility and presence are closely linked. Presence is a necessary condition for tangibility. We can only touch an object, if it is present. If we touch an object, we and the object are both present in the same space – at least in a mediated way.

In a broad sense, the sonically tangible cube relates to all projects, where virtual objects are perceived as present in real space. In particular, it relates to those projects that use sound and/or tangible interaction to convey the presence of (invisible) virtual objects in real space.

A project where the presence of something virtual is perceived tangibly is Sekiguchi, Hirota, and Hirose's (2005) so-called Ubiquitous Haptic Device. The little box, when shaken, conveys a feeling of a virtual object being inside the device. Similarly, a wearable

haptic device by Minamizawa et al. (2007), called the Gravity Grabber, allows participants to perceive the ruffle of the water in a glass, although he/she actually is holding an empty glass.

Projects that let a participant experience the spatial presence of “something that is not really there” by means of sound are Cilia Erens’ and Janet Cardiff’s sound walks (Erens, Cardiff, cf. Schraffenberger and Heide 2013b). Both artists use binaural recordings of everyday sounds that blend in with the sounds present in the real environment when the participant navigates the space and listens to the composition on headphones. Listening to the binaural audio creates a hybrid space in which the virtual and the real coexist, relate to one another and create “a new world as a seamless combination of the two” (Cardiff).

A discussion of Janet Cardiff’s work by Féral (2012) also helps our understanding of sonically tangible objects. The researcher defines “presence effects” as the feeling that an object (or body) is really there, even when one knows that it is not. This relates to the experience of the sonically tangible cube. While the ears make it feel as if the cube is present, the lack of tactile (and visual) stimuli informs us that nothing is there.

3.2 Open Air Instruments & Sound Installations

Our project relates to the field of sonic interaction. In particular, it relates instruments and installations that use hand or body gestures in free space to produce sound, such as the above mentioned Theremin. Like our research, such gesture instruments and installations are based on a mapping between body movement and sound.

The artwork ‘Very Nervous System’ (1986-1990) by David Rokeby is an early example of an interactive sound installation where body movement in open space generates sound. However, the sound of such artworks and instruments like the Theremin usually does not appear to originate from the location of the movement, which is a key difference from sonically tangible objects. Furthermore, with few exceptions, they do not (try to) express the presence of virtual objects in space.

One exception – an instrument that actually does convey the presence of virtual objects in space – is the invisible drumkit by Demian Kappenstein and Marc Bangert (*The Invisible Drums of Demian Kappenstein and Marc Bangert*. 2011). In their invisible setup, each virtual drum is placed at its regular position in space. Hitting the invisible virtual drums triggers pre-recorded samples of a real drumset. The position of the sticks and the speed of the movement determine which sample is triggered. Similarly to

the cube, the virtual drum kit becomes perceivable through the interaction.

3.3 Human-Computer Interaction

One possible area of application for sonically tangible objects is the field of Human-Computer Interaction, and in particular intangible displays. Intangible displays are visual virtual interfaces that appear in mid-air, in front of a user's eyes. Aside from simply displaying information they also allow for interaction: Users can touch virtual objects, such as buttons, with their physical hands. However, intangible displays do not provide tactile feedback when they are touched. Chan et al. (2010) address this lack of tactile feedback by providing visual and audio feedback. In their experiments, they played short sounds whenever participants touched the surface of the intangible display. Their project differs in the sense that sound is used to inform the user about the fact that they have successfully touched the object (as feedback) and not as an integral part of the object.²

Another related HCI project is the so-called BoomRoom (Müller et al. 2014). In this room, sounds seem to originate from certain spots in real space (this is realized with a circular array of 56 loudspeakers and Wave Field Synthesis). These sounds can be 'touched' in order to grab, move and modify them. Although related, their project differs in the sense that it focuses on the localization and direct manipulation of sound rather than on the presence and tangibility of virtual objects.

3.4 Perception

Haptics

The sonically tangible cube is perceived by explorative hand gestures. This links it to the field of haptics. Haptic perception typically involves active exploration (Lederman and Klatzky 2009). Haptics is commonly understood as a perceptual system that derives and combines information from two main channels: kinesthetic perception and cutaneous sensation (Lederman and Klatzky 2009). Cutaneous sensation is derived from the receptors that are found across the body surface and that allows us to feel, for example, pressure or temperature. The kinesthetic channel refers to perception of limb position and movement in space, which is derived from the receptors embedded in muscles, tendons and joints.

Kinesthetic perception also plays a key role in the perception of the virtual cube – it provides the participants with the

² Although originally not intended this way, the concept of sonically tangible objects could be used to improve the interaction with intangible displays. It could increase the spatial presence of the display, provide better feedback about the users hand position and movement through the display and is likely to make the "the awkward feeling of 'touching' a mid-air display" (Chan et al. 2010, p. 2626) less awkward and more tactile-like.

information about where and how fast their fingers are moving in space. This awareness is crucial in order to link what one hears to one's movement in space. What makes the perception of the sonically tangible cube different from common haptics is the lack of cutaneous feedback (including tactile sensations). Rather than 'feeling something at the position where they touch an object' the participants 'hear something at the position where they touch the object'.

Tactile Illusions and Cross-modal Interactions

The sonically tangible cube aims to create a tactile-like experience. There are several studies that indicate that sound can influence actual tactile experiences. The "Parchment-skin illusion" (Jousmäki and Hari 1998) shows that modifying the sounds that accompany hand-rubbing can influence the tactile sensation of the skin. It was found that accentuating the high frequencies can lead to the experience of a higher level of skin roughness. Hötting and Röder (2004) have discovered another auditory-tactile illusion. In their experiment, one tactile stimulus was accompanied by several tones. As a result, participants reported that they perceived more than one tactile stimulus. What sets these illusions apart from our cube is that in both cases, the participants were presented with a tactile stimulus.

Sensory Substitution

The cube relates to projects that use sound to substitute touch. One such sensory substitution system is F-Glove (Hafidh et al. 2013). This haptic substitution system aims at helping patients that suffer from the symptoms of Diabetic Peripheral sensory Neuropathy, such as sensory loss at the fingertips and resulting difficulties with manipulating objects. F-Glove uses audio feedback to inform the patients of the pressure they apply to objects. The volume of the sound is mapped linearly proportional to the applied pressure. Unfortunately, it is not clear whether the system simply informs the patients of the pressure they use via sound or whether they start experiencing pressure directly, via the auditory sense. Naturally, the experience of the cube is quite different from not having a sense of touch, as your hand can simply reach through the virtual sonic object.

4 Reflection & Outlook

With the sonically tangible cube we have introduced a prototype of a sonically tangible object and a new, sound-based form of augmented reality. The proposed cube is invisible and non-tactile. According to our experience, it is nonetheless perceived as spatially present in our real, physical environment. This suggests that virtual objects do not have to look or feel like real objects in order to be a believable part of our real, physical space.

The virtual cube is non-tactile and yet tangible. The experience of the cube can be seen as one possible answer to the question of how it could feel to touch an object that provides no tactile feedback. According to our impression, the virtual sonic object offers an almost-tactile experience that has no equivalent in a purely physical world. However, this still has to be confirmed by experiments with unbiased participants.

The current implementation of the cube primarily serves as a proof of concept. While we are happy with its current state, we have many ideas on how to improve the cube and explore the concept of sonically tangible objects further.

Concerning the sonic qualities, future experiments can reveal which sounds are most suitable for creating tactile-like experiences and possibly test whether sounds that are created with the hands work best. It would be interesting to find out more about how to sonically represent imaginary material and communicate different densities, textures and shapes with sound.

So far, we have chosen to work with binaural recordings. In the future, it will be valuable to explore computational methods for simulating the sounds' origins in space. If this is successful, it will be much easier to allow participants to move through space freely and experience the cube from different positions. Furthermore, it will be simpler to create polymorphic sonically tangible objects of different shapes and sizes and to place them at various positions and in different spaces.

One aspect that was left aside so far is the topic of (in)visibility. This offers several intriguing directions for future research. For example, we are eager to learn how participants interpret the absence of visual clues. On the one hand, it might lead to a contradiction between senses: "I can hear it, but I see that nothing is there". On the other hand, it could be interpreted as a *property* of the object: "Something is there, it is *invisible*". Further, it would be interesting to compare the experience of the cube with open and closed eyes, and, as an additional condition, also add a visual dimension to the cube (e.g., by means of a head-mounted display) to learn more about the influence of (in)visibility on the experience.

One limitation of this research is that so far, our inferences are based on informal tryouts and our own subjective experience with the cube. Our experience might not fully represent how others perceive the cube and we cannot entirely rule out the possibility that it is influenced by the expectations and hopes we have for the project. We plan to extend the presented research and conduct experiments with unbiased participants in the near future.

Due to its interdisciplinary nature, the project has also raised questions that go beyond our own area of expertise. For example, it would be interesting to learn more about what happens on a perceptual level. Are sound and kinesthetic information combined, similarly to how cutaneous information and kinesthetic information are integrated in traditional haptic perception? Can the combination of spatial sound and kinesthetic information lead to cross-modal interactions? What happens if the spatial information of the audio does not match the position of the fingers? Do we perceive the lack of tactile stimuli as “something missing” and do we fill in this information? We have put much emphasis on describing the concept in a way that allows other researchers to reproduce it and join our investigation of sonically tangible objects.

Acknowledgements

We want to thank all participants, colleagues and friends who interacted with the sonically tangible cube and/or provided feedback throughout the development of this project. In particular, we want to thank Wim van Eck for creating the image of the cube. Furthermore, we want to thank the reviewers for their valuable response.

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Making a Magic Lantern, Horror Vacui Data Projector

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Keywords: Magic lantern, horror vacui, glass art, electronic art, creative data imaging, digital manufacture, waterjet cutting, computation, aesthetics, algorithm, interdisciplinary collaboration.

This paper describes the creative process behind an artwork that combines and projects data in sculptural ways. This projection comes in the form of a reimagined magic lantern device called the *Magic Lantern Horror Vacui Data Projector*. This device is the result of collaborative glass art and electronic art techniques. Central to the projection system are re-envisioned glass magic lantern slides. No longer flat, they are squat six-sided boxes made entirely of glass. These slide boxes are filled with data-representational glass forms through which light is projected. The projected images are emitted from a three dimensional aggregate of data represented by coloured pieces of transparent glass. The appearance of the projection is manipulated by positioning these slides along varying axes through servomotors. Code is being developed to read input from the projection, generate additional data, and control the positioning of the boxes.

1 Introduction

Horror Vacui: In visual arts, it is the fear of leaving empty spaces unadorned. (Ettinghausen, 1979) In science, horror vacui refers to the physics postulate of ‘nature abhors a vacuum’. (Grant, 1981)

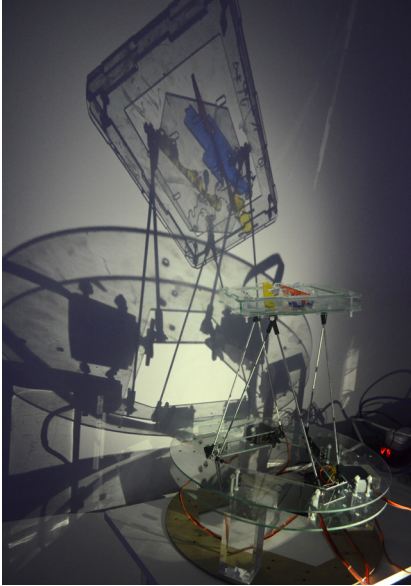


Fig. 1 *Magic Lantern Horror Vacui Data Projector*, 2015, Glass, servomotors, Arduino microcontroller.

The *Magic Lantern Horror Vacui Data Projector (MLHVDP)* uses analogue projection, creative glass and electronic art techniques that integrate and re-process data cyclically using sensors and servomotors. The term *horror vacui* relates to the function and appearance of the device as it is filled with data. The creative benefits of this project are that it combines illuminated kinetic glass sculpture and performative computational modes to counter the usually tacit, inadvertent, and invisible process that data undergoes as it is transferred through networks.

The projector uses clear and coloured glass segments to represent data. The transparent pieces, placed by a projectionist, connect and overlap in the visual arts sense of horror vacui; a fear of empty spaces. These palimpsestic shapes are seemingly indecipherable at first. While the data forms may seem arbitrary and practically unintelligible, they will be entered into a system that reads and re-interprets their shapes and imagery. The tension caused by this abstraction and organisation relates to Ettinghausen’s description of managing chaos through tessellated tiling techniques in Islamic art.

Each unit is then completely filled with a design, or at least as close as possible. Although the motifs are now repetitive, the horror vacui is again managed in an esthetically satisfactory manner. (Ettinghausen, 1979)



Fig. 2 *Glass Slide Box with data projection*, 2015, Waterjet cut fusing glass.

The ‘satisfaction’ Ettinghausen describes in relation to tiling motifs, here, relates to the mediation of data by a projectionist who collates and illuminates the information by arranging and constructing interlocking 3D glass shapes inside of the boxes. The way that glass represents data is through colour-coding; assigning each colour and shape a category and value. This data is being collected from weather and location tracking sensors through a collaboration with researchers at The Centre for Doctoral Training in Cloud Computing for Big Data at Newcastle Science Central.

The main objectives of this paper are to demonstrate an alternative to familiar modes of data display by screen-based computing devices and to extend creative collaboration between glass and electronic art. The aims supporting this objective are; to reinterpret artistic precedents as inspiration for developing an analogue, manually interactive and multidimensional system of

data representation and to develop code to govern the operation and interpretation of the device.

2 Influential Artworks



Fig. 3 *Raree Show*, 2009, Bradbury, Hornell, NY, USA.

The *MLHVDP* draws upon processes used previously in the authors' respective art practices. Victoria Bradbury has combined antique magic lantern technologies with digital/analogue projection and personal data with performativity. Mark Hursty has implemented pressed glass and waterjet cut glass techniques through creative and innovative applications. The *MLHVDP* is also influenced by Fabio Lattanzi Antinori's *The Obelisk*, 2012 and Semiconductor's *Data Projector*, 2013, both of which combine sculptural elements with data. Finally, Joseph Cornell's 1936 found footage film, *Rose Hobart*, is related to this project as an art historical reference.

In *Raree Show*, 2009, Bradbury live-projected 116 hand-drawn magic lantern slides using a 1940's opaque "Radiopticon" projector. The imagery appeared on a screen on the side of a sculptural circus wagon. The performance portrayed alternate outcomes of networked culture paired with financial collapse. The use of magic lantern techniques and slide performativity in *Raree Show*, 2009, influence the use of analogue slide projection in this new project.

In *Data Raft*, 2014, Bradbury created a forum for gallery visitors to retrieve and re-contextualise their personal data. Code and making processes were used to transform email metadata from intangible and private to tangible and public. A participant built a stick raft, attached a bespoke computer embroidered sail with their select data points, and set the vessel afloat on pools installed in the gallery.

This work underlines the performativity of the programmatic processing that data undergoes online. Data points are frozen in time as they are removed from the browser and embroidered on the sails. While engaged in a hand craft process, participants are temporarily unable to use their mobile devices to unconsciously generate additional data for the network. *Data Raft*, 2014, led to *MLHVDP*, which aims to abstract data through projection and sculptural means.

Central to the *MLHVDP* are the transparent glass slide boxes. These boxes, and the methodology behind their creation, emerged from Hursty's work with waterjet cut transparent pressed glass moulds in a series called **Puzzle Boxes**, 2014. In that on-going research, the one-time use boxes are filled with molten glass and then pressed with a central glass plunger, which fuses all of the elements as one object. The mould-pressing process itself illustrates horror vacui as the mould's voids are completely filled with glass. Using hot glass also resonates with Edward Grant's



Fig. 4 *Data Raft*, 2014, Bradbury, Sunderland, UK.

description of ancient horror vacui experiments, most notably with burning candles.

“Amongst the most striking illustrations that nature abhorred a vacuum were those employing fire and heat.” (Grant, 1981) The boxes were conceived to replace, in a didactic sense, opaque metal press moulds, so that practitioners can see how the molten glass behaves as it fills the mould crevices. The significance of this grew as fusing a mould into the finished object changes how that mould can be perceived; from a temporary apparatus to an essential component of the finished artwork. This methodological problematising of ancient craft precedents is also at work in the *MLHVPD* through reinterpreting projection devices and data display.

Fig. 5 *Puzzle Box Press Molds*, 2014, Hursty, waterjet cut fusing glass, Glass Art Society Demonstration, Chicago, IL, USA.

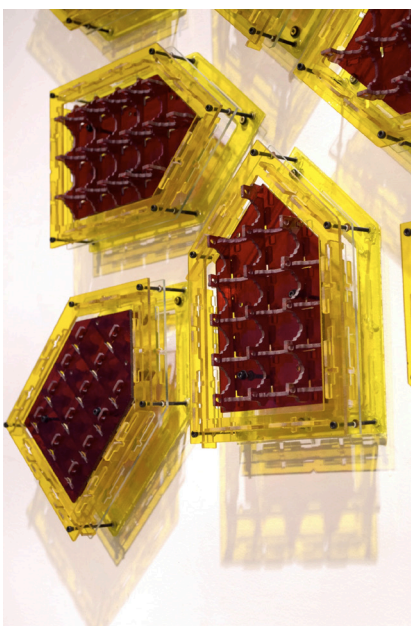
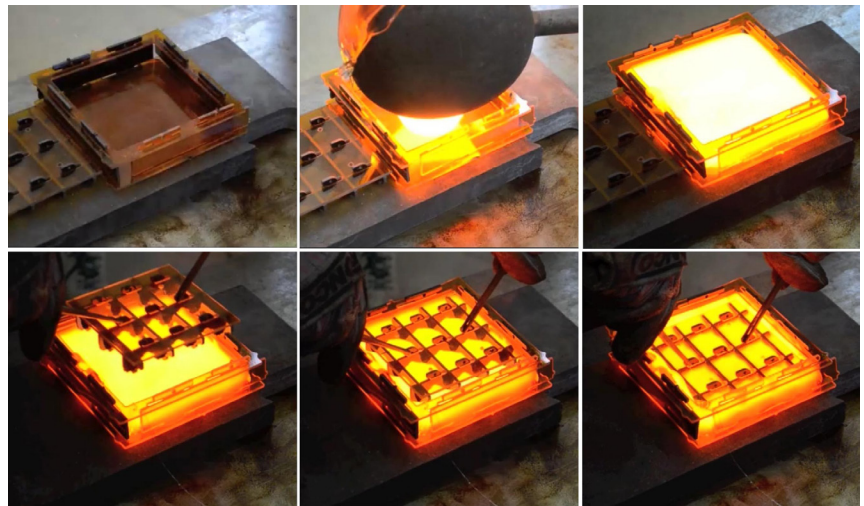


Fig. 6 *Puzzle Boxes*, 2014, Hursty, Shanghai Museum of Glass, China.

The process of making melting glass boxes requires complex glass-to-glass joinery with no metal fasteners. This is because the coefficient of expansion (COE) of glass is different than that of most metals. The negative result of differing COE are cracks where the different glasses or metal fasteners intersect and join. Where fasteners were needed for the *Puzzle Boxes*, they too were made out of glass so that they would also melt into the final box. Such complex joinery led to the title of *Puzzle Boxes*. Assembling them was like manipulating Chinese puzzle boxes, wood or ivory puzzles that were exported to the West in the nineteenth century.

While experimenting with molten glass and exhibiting the *Puzzle Boxes*, it became apparent that the boxes themselves acted as miniature projection devices. With only natural light as a source, they were like opaque projectors with light transmitting through their structural elements and projecting compelling detail on nearby surfaces. This discovery sparked the idea to use the boxes as the basis for a system of analogue projection. The *MLHVPD* for sculptural data projection is the first result of such a system.



Fig. 7 *The Obelisk*, 2012, Fabio Lattanzi Antinori.

Fabio Lattanzi Antinori's *The Obelisk*, 2012, serves as a precedent for pairing data with a sculptural glass object. Here, data, based upon a live feed of news stories about crimes against humanity, controls the levels of opacity of a box. The box is made of sheet glass (or Perspex) and electrochromic film, which changes from opaque to transparent depending upon whether electrical current runs through it. The streaming data causes each side of the box to independently alternate from opaque to transparent. This creates variable views of how the box and the sculpture behind it can be seen. Connections can be made between the clarity of the boxes' facets, war crimes, and levels of awareness raised by their reported descriptions in the media. Whereas *The Obelisk*, 2012, is static and is viewed in both transmitted and reflected light, the slide boxes in *The MLHVDP* are physically in motion and depend on transmitted light to be projected.¹ The formal difference between the two approaches is that Lattanzi's work is encountered by looking at the glass box directly, while Hursty/Bradbury's is meant as a type of lens that directs and focuses light elsewhere.

Fig. 8 *Data Projector*, 2013, Semiconductor.



The art duo Semiconductor, Ruth Jarman and Joe Gerhardt, created *Data Projector*, 2013. This piece offers a creative example of integrating digital projection, sculptural forms, and data processing. It uses data gathered from a forest, charting the tree canopy from the vantage point of an observation tower over the course of a year. According to the artists, "There's a sense of the hand made at work; the clunky tower and the hand-made carbon paper, suggesting the presence of man as observer trying to make sense of the world. Yet, there's also a precision which comes with the data, bringing structure and rhythm and creating a sense of complexity to what we see and hear. This conversation between analogue and digital plays with the divide between how science represents nature and how we experience it." (Jarman and Gerhardt, 2015)

¹ A concise distinction between the transmitted and reflected light follows in this example from microscopy. "A trans roscope mitted light michas a light source below the microscope stage and sends light upwards towards the sample and up to the viewing point. A reflected light microscope has a light source above the sample and what is seen though the view point are light waves that have reflected off the sample."



Fig. 9 *Rose Hobart*, 1936, Joseph Cornell, found footage film.

² In 1936, Cornell debuted *Rose Hobart* at the Julien Levy Gallery in New York City. His film, the footage for which he scavenged from destruction, drastically re-edits the feature film *East of Borneo*, 1931. This recontextualisation of *East of Borneo*'s subject matter was emphasised by Cornell's choice to project *Rose Hobart* through a tinted piece of blue glass. In the audience at the gallery were André Breton, Salvador Dalí and other contemporaries who were participating in the MOMA's first surrealist exhibition of 1936. Dalí's absurd, and apparently jealous, reaction to the film was to knock over Cornell's projector and call him a thief. Dalí claimed to Levy that, "My idea for a film is exactly that, and I was going to propose it to someone who would pay to have it made... I never wrote it or told anyone, but it is as if he had stolen it." (Solomon, 1997)

The structure, rhythm and complexity Jarman and Gerhardt mention is emphasized in the unusual, round-shaped projections that are a result of recording the forest canopy in 360°. The *MLHVDP* also uses attributes of analogue construction. Its structural apparatus, the slide boxes, serve as an architectural framework in the way that the wooden observation tower does in Semiconductor's piece. In the *MLHVDP*, however, the architectural components also function as a lens for the data and as the data itself. The result of this condensed form and function are projections that are asymmetrical rather than rectangular, as in familiar modes of data display.

Rose Hobart, 1936, is a pioneering found footage film by the American surrealist artist Joseph Cornell. The film was significant as a new way to gather, process and project film. This significance is reflected in the creation and use of data in the *MLHVDP*. Also influential to this new work was a notorious incident that occurred the first time *Rose Hobart* was shown.² During the film's debut Salvador Dalí knocked over the projector and accused Cornell of stealing the idea of found footage film from Salvador Dalí's subconscious.

Several aspects of the *MLHVDP* are summed up in this incident. First, Cornell's unorthodox use of collected and re-edited footage offered a new way of seeing and reading the content. Found footage filmmaking can be compared to physically salvaging data then reorganizing it, reinterpreting it, and re-projecting it; even down to reorganizing the mechanics of projection in order to obtain a new understanding of the material. Second, when Dalí knocks over Cornell's projector and claims that Cornell stole his subconscious idea, the projector becomes a proxy for Cornell himself. Dalí's violence is directed toward the mechanics of the projection. This mediates the ramifications of content on the projectionist, with violence directed through the projection device.

The essential dynamic of this relationship is re-performed by the *MLHVDP* in a loop of data collection and visualisation that has been abstracted, projected then reinterpreted through code. With respect to who collected the data and how (the researchers through sensors), and who abstracted the data and how (the authors through projection), this dynamic emphasizes a creatively constructive and malleable view of attribution.

The above artworks represent different approaches that are reflected across the iterations of the *MLHVDP*. Like the *MLHVDP*, their combined methods problematize the mechanics of projection, challenge orthodox screen-based modes of data display, and serve as a provocation for how data can be collected and processed.

3 Developing the Magic Lantern Horror Vacui Data Projector

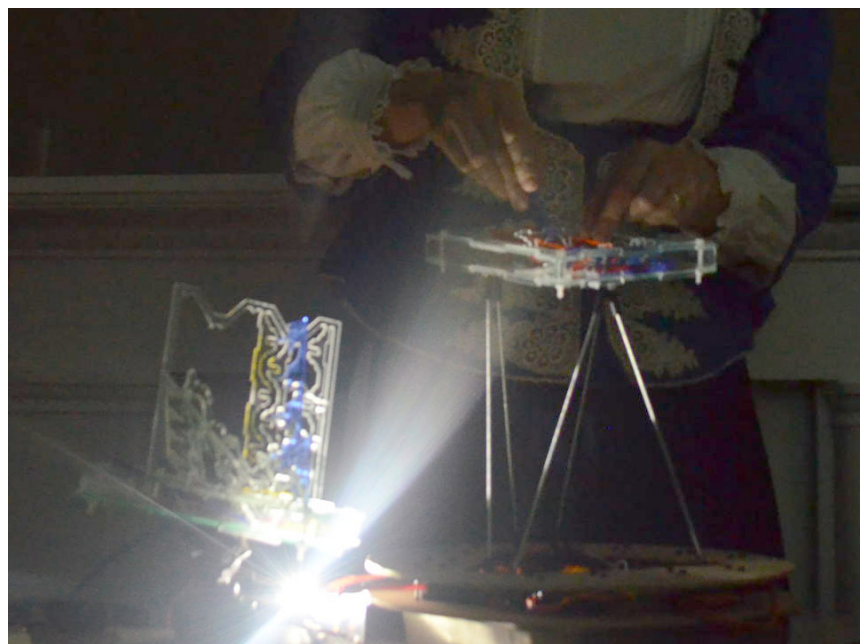
3.1 Making the Projector

The *MLHVPD* has been developed through a series of steps. The glass was designed, cut and constructed at the National Glass Centre at the University of Sunderland; the projector was performed at Gateshead Algorave #2; it was exhibited through Gateshead Arts and it is being further developed through the use of site-specific data.

The glass components of the projector base and slide boxes were constructed through waterjet cutting. The slide boxes were assembled atop a transparent Stewart platform to allow light to pass through. In this way, the light source could be placed either above or below the motors. If placed below, the mechanics of the base are projected in addition to the glass boxes (Figure 1). The platform has servomotors at the base, which are programmed through an Arduino microcontroller. At the Algorave, this kinetic work was performed live as Bradbury added and subtracted transparent coloured pieces within the glass box. A variety of light sources were tested to project through the glass onto the walls of the performance space.

Observations from the Algorave performance indicated that the projection is most complex and engaging when the glass boxes are filled with three-dimensional glass objects, which can be turned in space and evaluated from different vantage points. In comparison, a flat slide can only be viewed in one way. Tunnelling light through these transparent structures presents the edges,

Fig. 10 *Magic Lantern Horror Vacui Data Projector*, Performance, 2015, Gateshead Algorave #2.



three-dimensionally. The movements of the projected image are visually similar to toggling 3D computer rendered objects in virtual space.

Next, the authors are working with the cloud computing researchers who are providing weather and location tracking data sets that are specific to the city of Newcastle, UK and the building in which they work, The Core in Newcastle Science Central. As this collaboration develops, the researcher's data sets will serve as inspiration for how data can be encoded within the coloured glass structures, and, in turn how their projections can be decoded.

3.2 Properties of the Projector

The visual properties of glass that underpin the MLHVDP are clarity and uniformity of colour. If these qualities are used creatively, light can be transmitted through glass in stimulating ways that transcend its material reach. The physical properties of glass that underpin this device are that it is electrically inert, inflammable and archival. When the glass is projected, then read and re-interpreted by code, the enticing properties of glass, code, and data integrate and expand into new forms. These forms, unless broken, are permanent. Unlike digital archives, they will not degrade over time.

The glass data forms are encoded and decoded as they are projected. This coding process is twofold. The first stage is projected light in the form of a bespoke overhead projector. The slide box can be projected flat like a conventional slide, but it also has the range of motion to be rotated and tilted for 3D views. As it moves, variable perspectives of the sculpture illuminate the space. The goal of the second stage, which is still under development, is to create an algorithm that will read and interpret visual information from the projection, then re-position the slide box to frame certain vantage points.

While data is now predominantly considered and viewed in digital ways, Sara Diamond emphasizes its fundamental analogue nature when she states, "Data can be numbers, words or images. Data can be collected manually (as it has been for centuries), and then put into a computer." (Diamond, 2009) The *MLHVDP* returns data to an analogue, material state, contrasting this fragility and traditionally static nature of cold glass with the ephemeral, malleable nature of both data and projection.

The re-envisioning that this piece enacts allows us to apprehend multiple views of the 'data', a process that would normally be abstracted and highly obfuscated. These multiple perspectives could be helpful as a tool to visualize abstract data as concrete interconnected objects. What might be obvious in one view, may

present nuances in another. One example of this is seen in the edges of the boxes where the glass ‘data’ appears within dark contour lines. These lines maintain the projected illusion of turning an object in space. The advantage of this is that the data is made less abstract as it becomes a consciously sculpted, tangible object that is then re-abstracted for further interpretation through projection. This re-projection reflects a constructive distance from which the data can be evaluated.

4 Conclusions

This paper describes the artistic development of an analogue projection device for visualising data. The diverse influences include equating data collection with the horror vacui, or nature’s abhorrence of a vacuum; an altercation between Salvador Dalí and Joseph Cornell concerning attribution of the invention of found footage film making; the revival and reinterpretation of magic lantern projections and pressed molten glass; and the creative performativity of sculptural data. These coalesce in order to address contemporary questions of data attribution and generativity in a collaborative interdisciplinary artwork.

In further iterations of the *MLHVDP*, additional modes for interpretation of live-generated data may abrogate the horror vacui. This could mean that the device thereafter can be simply referred to as a “Magic Lantern Data Projector”. Anticipating that development will hinge on the effectiveness of the motorised slide platform and the light source in concert with the artist-written software.

The purpose of the *MLHVDP* is not only to present a new aesthetic to the portrayal of data, but also to offer potentially productive new techniques to the fields of new media and glass art. This new combination of modes arose by problematizing and performing a process of projection, obfuscation, and re-interpretation of data through a collaborative artwork. The resulting dynamic is intended to rethink staid representation, not only by what is projected, but also by the way each medium is perceived. In the case of new media art, these results could yield new ways to view data through analogue projection and sculptural means. This multidimensionality could also serve to expand and diversify the appeal of glass art and glass slide projection, not merely out of a sense of nostalgia for manual participation and material specificity, but as innovative and content-generative media in their own right.

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ZoOHPraxiscope: Turning the Overhead Projector into a Cinematographic Device

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Keywords: Cinematography, Media Archeology, Overhead
Projector, Zoopraxiscope

The ZoOHPraxiscope combines the overhead projector with a spinning picture-disc and it works similar to the Zoopraxiscope. The Zoopraxiscope is a historical device that was invented by Eadweard Muybridge to animate sequences of pictures. The ZoOHPraxiscope allows to combine direct animation and shadow play with cinematographic animation. Using custom made electronics to control both flicker frequency and rotation speed of picture-discs, it is possible to play with various regimes of animation. As motion and light flicker are directly coupled to sound, the device is also a performance instrument for audio visual performances.

1 Introduction

The ZoOHPraxiscope is a modified overhead Projector (OHP) and a re-implementation of a historical device for animating images, the Zoopraxiscope. The Zoopraxiscope was developed in 1879 by the photographer Eadweard Muybridge, to project and animate sequences of pictures showing animals in motion (Hendricks 1975). My purpose of modifying the overhead projector into a cinematographic device is not to create a detailed replica of the Zoopraxiscope, but to fuse two modes of animation in a playful way. In previous work I have used the overhead projector for creating shadow plays of moving objects, the first mode of animation. I use it for creating audiovisual performances (ray vibration 2015) and as philosophical toy to convey scientific insight about the theory of embodiment (Faubel 2013). The second mode of animation is based on cinematographic animation similar to the animation technique of the Zoopraxiscope. With the presented setup these two modes of animation, shadow play and cinematographic animation can be fused and mixed.

1.1 Early cinematographic devices



Fig. 1 A Zoopraxiscope disc, as it was used in the Zoopraxiscope developed by Eadweard Muybridge (source Wikipedia)

I refer to Eadweard Muybridge's invention of the Zoopraxiscope as device for displaying animated images, mainly because the device's name can be easily changes to ZoOHPraxiscope. I could have equally referred to Franz von Uchatiu's Kinetoscope or Ottomar Anschütz's Electrotachyscope. All these inventions and innovations share the technological combination of a picture disc (see Figure 1.) combined with a Laterna Magica and a shutter mechanism. All devices appear in a timeframe of only 45 years between 1845 and 1890 (Füsslin 1993). This era is often designated as pre-cinema, but as Zielinski writes this is a shortsighted reduction, because the variety of different approaches and of the motivations that drove the persons involved was too large (Zielinski 1999). What drove people like Muybridge or the chronophotographers Marey and Janssen was not the invention of cinema but the idea of using photography to reveal a deeper truth about the world (Canales 2011).

This quest for truth is well demonstrated in the biography of the photographer Eadweard Muybridge, who had developed an apparatus to prove that a horse has all the feet off the ground during gallop (Muybridge 1878). He used an array of photographic cameras connected to switches triggered by strings attached across the path the horse would run along. Using this technique, he succeeded in taking a series of photographs showing a horse with all feet off the ground during gallop.

The Zoopraxiscope is a device he then developed for animating such motion sequences and for showing these sequences to a broader audience.

1.2 The Overhead projector

When taken out of the context, where the overhead projector is known best, the classroom, instead of being boring as we remember it, the overhead projector is surprisingly fresh.

Take for example the performances of the group loud objects (loud objects 2015), using soldering irons they assemble electronic circuits that produce sound on the overhead projector. While one follows a shadow play of hands, soldering irons and smoke, at some point these shadow objects start to emit rhythms and sound and become loud. An other example are the performances by Klaske Oenema (Oenema 2015), a singer-songwriter and storyteller. While she sings, she unfolds a story using images that are scratched or drawn onto found transparent objects and placed on the overhead projector. I think that even though these two examples are very different in style, one being loud, noisy and experimental, the other being silent, harmonic and poetic they share the same magic, the magic of the *Laterna Magica* and of the shadow play.

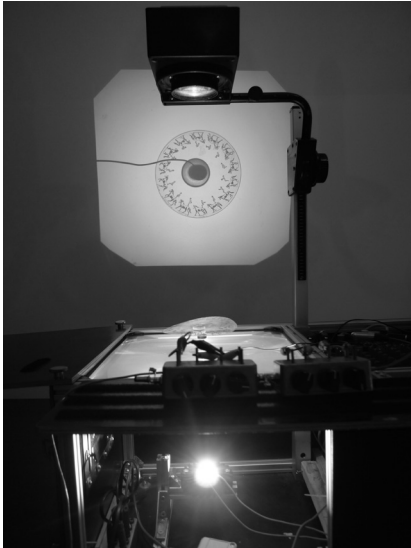


Fig. 2 The ZoOHPraxiscope, A custom build overhead projector with a high power LED as light source and a Zoopraxiscope-disc printed on a transparency

1.3 LED technology & cinematographic animation

I have been working on a technological update of the overhead projector, primarily driven by the wish to reduce its energy consumption in the context of a project for creating a mobile overhead projector¹. With the development of high power LEDs it has become possible to reduce the power consumption by a factor of ten and still deliver enough light intensity for classroom presentation. But most importantly for this project, it has also become possible to easily switch the light source on and off at the fraction of a second. While standard halogen bulbs have a non-negligible afterglow, a LED may be switched on and off at high frequency. The complicated mechanism of a film projectors shutter may be realized simply by turning the LED on and off. Combined with a rotating disc it possible to easily create an animation based on the principle of the Phenakistoscope.

This new possibility has triggered new interest in pre-cinema animation techniques and there are quite a number of projects making use of LEDs for creating animations. A recent popular example are the animation of three-dimensional objects (Smoot et. al. 2010, Dickson 2003).

¹ "Overheads on bike", A project in collaboration with Tina Tonagel and Ralf Schreiber, funded by ON – Neue Musik Koeln e.V.

There are a number of very good artistic projects that revive technologies such as Zoetropes, Phenakistoscopes or Zoopraxiscopes. A first example are the mesmerizing performances by the group Sculpture (Sculpture 2015), who use pictures-discs in combination with a high-speed shutter camera and a video beamer. A second example is the installation Kiss-o-scope by artist Amanda Long (Long 2015). She developed a custom software to render live streams of camera images into a Phenakistoscope display projected by a beamer. Common to these projects is that they feature an obsolete technology that has none the less never lost it's magic.

Combining the overhead projector with a high power LED and a rotating transparent disc allows to project to a broad audience but most importantly for combining direct animation and shadow play with cinematographic animation. This combination of direct and of cinematographic animation is the innovative contribution of this project.

2 Turning the overhead projector into a Zoopraxiscope

To use the overhead projector as a Zoopraxiscope requires to modify the light for being able to quickly turn it on and off and a system for creating spinning images.

2.1 Replacing the light bulb with a high-power LED

A standard overhead projector is equipped with a 250 Watt light system. It uses a 24 Volt Halogen lamp that is operated with a current of 10 Ampere. To provide such large amounts of current requires a big transformer that converts the 220 Volt Ac current into 24 Volt DC current. Because the halogen lamp is an incandescent lamp a lot of heat is produced. As a consequence most overhead projectors are equipped with an active cooling system. Because the lamp emits light in all directions a mirror is placed behind the light bulb to reflect the light in direction of the fresnel lens. In front of the lamp a diffusing lens is mounted that spreads the light so that the fresnel lens is illuminated homogeneously.

With the introduction of affordable high-power LEDs it has become possible to greatly simplify the overhead projector and to drastically decrease its power consumption, while providing approximately the same light intensity.

To run a 20 Watt LED a constant current provider is needed, these can be bought off the shelf. A 20 Watt LED that runs at 14 Volt will draw a current of 1.4 Ampere, which can be provided by very cheap and very small switch-mode power supply. High power

LEDs are arrays of LEDs that are mounted on a surface. The light they emit is directional and covers an angle of approximately 120 degree and no extra lens is needed to homogeneously illuminate the fresnel lens. High-power LEDs may be passively cooled, it is sufficient to mount them on large cooling block. All in all, replacing the halogen lamp with a LED is very simple and also simplifies the projector. The active cooling fan, the big transformer the optics with the bulb can be removed and leave ample space for installing a bigger cooling body with the LED mounted on.

2.2 Controlling the high-power LED

All standard constant current drivers for LEDs offer a pulse width modulation (PWM) interface for dimming. This interface is intended for dimming the LED, by turning it on and off at a high frequency at which no flicker is perceived. But it can operated at any frequency. In order to create the illusion of continuous motion from discrete images, the rate has to be at around 18 frames per second as in standard cinema.

A second parameter besides the frequency at which the LED is turned on and off is the duration of the on-state of the LED. This is an important parameter for continuously rotating picture-discs. In order to have stable image without motion blur the on-time has to very short. This short on-time corresponds to the thin slits in the classical zoetrope cylinder. When the slits are too wide the animated image is blurry (Füsslin 1993). Analogously when the on-time is too long the image becomes blurry.

Both parameters, frequency and on-time can be controlled with a very simple analog circuit, the bi-core oscillator (Hasslachner & Tilden 2002) (see also Figure 3.). While there exist other oscillator circuits, I use the bi-core, because it can also drive motors. This offers the possibility to couple the flicker frequency with driving the motor, in order to synchronize both. With the two variable resistors of the bi-core circuit, the on-time and the off-time can be controlled independently.

2.3 Driving spinning discs

To spin the picture-discs, I use standard dc-motors with a gearbox that directly drive the discs. The motors are mounted on a holder with a vacuum cup, so that the motors can be quickly positioned on the overhead projector. The motors carry an acrylic discs, that holds the picture-disc printed on a transparency (see Figure 4.). For controlling the rotation speed, again I use a bi-core oscillator. For creating a continuous rotation instead of an oscillation the potentiometer for the right spin is set to zero, so that the motor



Fig. 3 The bi-core unit, left potentiometer controls on-time of the LED, right potentiometer the off-time.



Fig. 4 The Picture-disc is mounted on a dc-motor. The motor is fixated with vacuum cup on the screen.

will only turn to the left. The speed can be controlled by a third potentiometer that controls the current for driving the motor.

2.4 Spinning discs and flickering lights

Being able to control both the flicker of the LED and the rotation of the spinning disc allows to play and search the magical moment when the animation appears. There is a huge parameter space in which the illusion of continuous motion is perceived. It starts at around 12 frames per second and goes up to 40 frames per second. The number of single images on the picture-disc and the rotation speed of the disc determine the number of frames per second. The flicker of the LED then needs to be adjusted accordingly, for example, a picture-disc with 16 images that makes one rotation per second requires 16 flickers per second.

2.5 Combining sound and vision

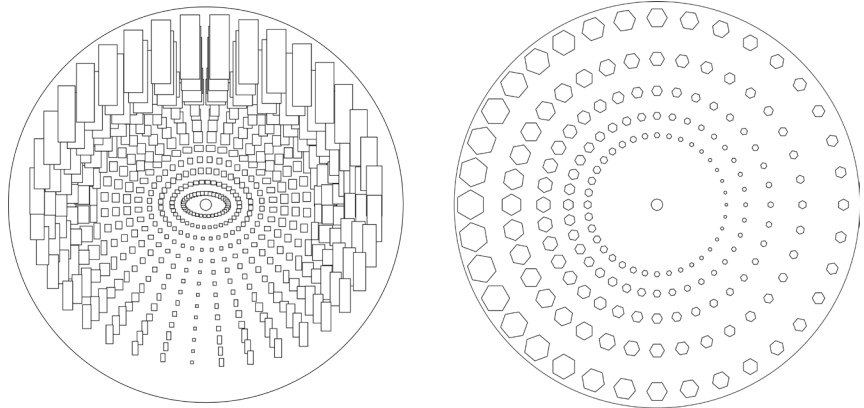
When used in the shadow play animation mode, the combination of sound and vision is based on directly listening to oscillatory signals that generate movement of a robotic structure, or to couple these signals to analog synthesizers. This technique of combining sound and vision is described in more detail in the paper *Rhythm Apparatus on Overhead* (Faubel 2014). The same set-up is used for driving the spinning picture-discs. Using an oscillator circuit to drive the rotation of the picture disc may seem counter-intuitive at first sight. But it allows to rhythimize the continuous rotation of the picture disc. At naked eye this rhythmic structure is not visible, the motor just seems to turn. But when the rotation is combined with flicker from the LED, not only the cinematographic animation becomes visible, but also rhythmic discontinuities in movement of the picture disc.

3 Software scripts for creating Zoopraxiscope picture-discs

I developed software-scripts to generate Zoopraxiscope picture-discs, using the software framework *processing*.² These scripts generate minimalistic animations of simple shapes, such as expanding hexagons, rotating and expanding rectangles, or triangles moving in circles. Figure 5. shows two examples of such picture-discs. The script to draw the rotating rectangles is shown below.

² <http://processing.org>

Fig. 5 Example Picture-Discs generated with the software. The left disc is generated by the script below, when animated it shows rotating rectangles, the right disc produces expanding hexagons.



```

num_frames=36;
void draw()
{
    pushMatrix();
    translate(width/2, width/2);
    rectMode(CENTER);
    rotate((-2.0*PI/(num_frames)*ctr++));
    for (int j=1; j<15; j++)
        for (int i=0; i<num_frames; i++)
        {
            rect(j*20*sin(i*-2.0*PI/num_frames)
                + 20*sin(i*-2.0*PI/num_frames),
                j*20*cos(i*-2.0*PI/num_frames),
                5+exp(j/5)*4*sin(2*PI/(num_frames*2)*i),
                5+exp(j/3)*2*sin(2*PI/(num_frames*2)*i));
        }
    popMatrix();
}

```

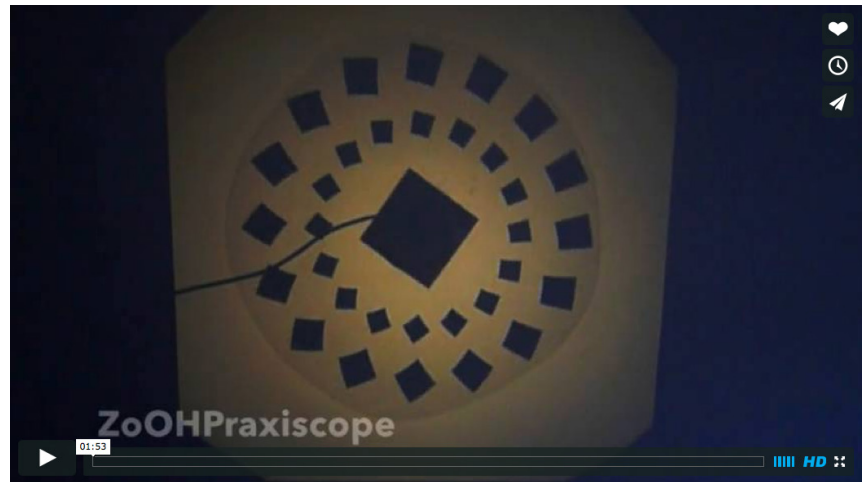
Code to generate the rotating and expanding rectangles, expansion is a function of the angular position and the distance from the center.

4 Playing with direct animation and with cinematographic animation

For playing with direct animation and cinematographic animation, I use basic shapes such as squares and print sequences of for example a rotating square on a picture disc with a single square at the center (see Figure 6. for an example). These basic shapes lend very well for mixing both animation styles. When used in in direct animation the center square rotates back and forth or appears as circle at high rotation speeds. In this mode what is special is that the signals that drive the motors are also used to generate sound. As matter of fact sound and movement are always in sync. Because of the rotation, the outer patterns smear out and are just

perceived as some texture. When flicker is turned on suddenly the outer shapes appear and are perceived as rotating. As the discs are turning at different speeds the clear perception of animation does not appear at the same time. Performing with this setup is really about playing with perception (see Video in linked in Figure 6.).

Fig. 6 A video showing an example of mixing direct animation with cinematographic animation (<https://vimeo.com/129420374>)



5 Conclusion & Outlook

I have presented a setup that allows the fusion of shadow play and cinematographic animation. It is based on a simple and cheap modification of the overhead projector. It is fun to play with these different modes of animation and tuning in and out of animation and flicker. Even for the cinematographic animation it is possible to drive the discs rhythmically. At the naked eye the discs seem to be rotating continuously, when flicker is turned on the animation seems to stop rhythmically. As the signals driving the rhythms are connected to sound, even for the animation the sound is in sync with these rhythmical stops of the animation.

As the modification of the overhead projector is really easy and cheap, I plan to develop a workshop for modifying the overhead projector. In this workshop participants will learn very basic skills on electronics but also in a second part they will start experimenting with animation. While it is handy to use a software to print out picture-discs of animations, it is also much fun to work on animation directly by, for example, drawing simple shapes by hand. The key element of the workshop would be based on this tangibility of animation.

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Short-Papers



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Accidental Aesthetics: Philosophies of the Artificial

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Keywords: artificial aesthetics, philosophy, speculative realism

This paper will examine a range of philosophies surrounding aesthetics and begin to speculate on a metaphysical framework surrounding artificial aesthetics. Tracing earlier arguments from Hegel and Kant and extracting significant developments in newer variants of speculative realist philosophies, this paper seeks to critically engage the realm of aesthetics and computation from a metaphysical viewpoint. These metaphysics touch on issues of non-human agency, inter object relations, and aesthetic theory in relation to computational entities and autonomous systems. The ability of these systems to operate outside of human cognitive limitations including thought patterns and constructions which may preclude alternative aesthetic outcomes, afford them in some ways limitless potential in relation to aesthetics. Aesthetics here are not narrowly constrained by a human ability to recognize or appreciate these outputs. The designation of the accidental or provisional is utilized as an alternative approach to the production and assessment of aesthetic occurrences.

1 Introduction

An exploration into accidental aesthetics posits that outcomes, products, thoughts and recognitions of the aesthetic are related to an unfolding and singular relation or encounter which is not expected whether in behavior, form, affect or outcome. This is in line with existing conceptions of human aesthetic breakthroughs requiring novelty in some regard whether it occurs through medium, point of view or technique. We can designate that this is a persistent feature of the realism of the present moment. In a certain sense every unfolding encounter could be described as accidental, namely that there exist probabilities in relation to effects from past causes but not absolute certainty as to the exact effects. My assertion here of the pervasiveness of the accidental as an underlying feature of the aesthetic stands in opposition to the more commonplace view of the term accidental as a throw away or pejorative designation. Here it is interpreted as a desirable and affective feature, one that is both ubiquitous and yet under examined philosophically. The accidental alludes to perceptions, interactions, causes and effects not entirely premeditated or conceived, nevertheless yielding effects both discernable and registered. This would apply to both human and non-human instances. Imagining the potential for a drastically diverse range of aesthetic instances and affective capacities will provide us with an expanded concept of the potentials for artificial entities in both form and behavior.

2 The Poetics of Conventional Aesthetics

The vantage point of the accidental stands in contradiction to outdated ideas that the aesthetic resides in a distinctly human approach which can be seen throughout historical philosophical focuses on aesthetics. The aesthetic as a term and an area of philosophical inquiry has posed significant challenges due to the elusive nature of capturing and locating the aesthetic. Hegel in his *Lectures on the Introduction of Aesthetics* in the 1820's recognized that, "a study of this kind becomes wearisome on account of its indefiniteness and emptiness and disagreeable by its concentration on tiny subjective peculiarities" (Hegel, Knox transl., 1979). This indefiniteness and emptiness can be identified as a pertinent feature of the aesthetic. When we are dislodged from our default mode of interpretation and cognition, when the present moment unfolds with unexpected variability, a disruption of our cognitive expectations occurs and we experience a sort of indefiniteness. This disruption and its affective capacity can be predicated in one's own aesthetic encounters with any number of phenomena which may then be translated into aesthetic products

or simply remain in a singular aesthetic experience with oneself. The question then becomes, can artificial systems embody indefiniteness? This question could return to the sensual realm the artificial embodies. Autonomous systems and artificial entities have continuously evolving inputs be they informational or physical and they are capable of registering each new composition of sensory inputs as unique and singular encounters. The structuring and legibility of this registration is highly variable and could be expressed through generation of an aesthetic activity, output, artefact or relation. The way these entities register disruptions when encountering something novel and the outputs they may enact in response is an area that warrants greater metaphysical attention in relation to aesthetics.

The one consistent feature in discussions of the aesthetic involves the presence of an aesthetic void which eludes precise description or location, both cognitively and materially. The advent of computational processes calls into question this unnamed process which has been referred by numerous evocative yet vague adjectives and nouns including cloudy, the essence, the rift, the remainder, etc. It is clear that aesthetics pose significant challenges in delimiting and describing what exactly they are. Steven Shavero discusses Kant's statement that there is, "no science of the beautiful" (2009). The aesthetic realm has traditionally been understood to arise out of such mysterious workings in addition to summoning contemplation or recognition of such mysteries through an affectual quality. The aesthetic process and its related affects cannot be located to one key mechanism whether physiological or material. It eludes specific definition and resides alongside other mysterious and opaque processes relating to emergent phenomenon in human and nonhuman complex systems. This aesthetic void removes itself from direct contemplation or description and is a persistently fuzzy and elusive entity. Examining approaches to translation, metaphor and symbols are often helpful as they also coincide with considering how the realm of the aesthetic meets the binary.

3 Non-human Aesthetics

In order to move from a traditional approach to aesthetics which hinges on human subjectivity and issues of taste, and discernment, an examination of current approaches to non-human aesthetics provides a potential way forward. There have been several recent works that attempt to reconcile non-human aesthetics. Recent influential work includes David Rothenberg's compelling book, *Survival of the Beautiful* which locates beauty as a fundamental part of evolutionary processes and discusses non-human

aesthetics in a compelling manner (2011). Recently Tom Sparrow has put forward a compelling argument that we are at the end of phenomenology charging that it is, “no longer apparent how phenomenology is to be carried out or how it differs from, say, thick empirical description or poetic embellishment” (2014). Phenomenology has concerned itself with the sensual realm and has frequent overlap with the aesthetic. Poetic embellishment is often a symptom of this work. When faced with this gap (rift, chasm, unknown, the remainder...) poetics and their affective quality act as an intermediary plane of communication. In their affective abilities they utilize this not quite here, not quite there, dislocation. Poetics belonging to the aesthetic realm allow us to probe and hint at the sense we may gather from the “real” but cannot be described or located in any specific way. The ability to transport, disrupt and point attention to a dislocation from established patterns, identities and constructions aligns with my conception of the accidental as a fundamental feature of all aesthetic phenomena recognizable or not. Therefore, although the phenomenological method in its insistence on the subject/object distinction is admittedly flawed, the phenomenological realm, that of sensation still has much to offer in our contemplation of this void. In their affective communications, poetics and other aesthetic communications may rub up against and glimpse the “real” much more accurately than metaphysical descriptions.

There is something to be discovered through deploying phenomenological methods to speculate on computational embodiments. This would include thinking about how these entities see, feel and comprehend the world through a variety of hardware and software including advanced sensing capabilities at extreme scalar ranges eluding human perception. In addition there is a staggering variety in the way these systems could eventually operate in terms of both input and output capacities. Ian Bogost’s book, *Alien Phenomenology* puts forth a compelling account of how various machines and devices “see” (2012). This sort of phenomenological approach is not meant to be an anthropocentric reading of how machines will be like “us” but rather a means to speculate on the variety of ways they will be quite different. Their potential for a more diverse range of outcomes could present us with new understandings of what embodiment looks like from radically diverse points of reference. This in turn hints at new potential aesthetic outcomes. It is only when we limit our phenomenology to human embodiment do we close off any potential access or insight into artificial aesthetics.

4 Speculative Aesthetics

A speculative realist philosophy is well suited to contemplating aesthetics of the artificial. By operating outside of the traditional anthropocentric lens, these philosophies are primarily interested in examining what lies outside of our traditional perceptions and assumptions. The endless proliferation of objects or things is a main focus of Tristan Garcia's *Form and Object*. He states the problem at hand:

...there are more and more things. It is increasingly difficult to comprehend them, to be supplementary to them, or to add oneself to oneself at each moment, in each place, amidst people, physical, natural, and artefactual objects, parts of objects, images, qualities, bundles of data, information, words, and ideas – in short, to admit this feeling without suffering from it. (2014)

As more and more things are connected and networked the number of instances, objects and thoughts that can arise in relation to these multiply and intensify. Our ability to name, identify and verbalize these becomes tricky. How many phenomena do we even have words for? The aesthetic develops, accentuates and manufactures its own set of unique relationships between its internal elements, its external relations and any phenomena it invokes or brings into being. These remain in the gap. Hard to describe and name, yet real in every sense. Timothy Morton in *Realist Magic*, describes one particular type of disruption in perception through the experience of jet lag: "... things are strangely familiar and familiarly strange – uncanny. Then it hits you: this is the default state of affairs, not the world in which regularly functioning things seem to subtend their aesthetic effects...The smooth world is the illusion! The clown-like weirdness of the uncanny situation you find yourself in..., is the reality" (2013). The presence of the uncanny is one specific type of aesthetic encounter which announces itself without any direct intention.

From a speculative realist point of view any so called designation of *realism* itself is irrational and uncategorized. Autonomous systems instead of being modelled after our views, aspirations, goals or "feelings" could instead operate from a deliberate stance of irrationality. Novelty is a distinguishing feature of my argument of the accidental. In this sense an artificial system seems primed to substantially contribute to aesthetic production. Once we begin to formulate that interactions however slight are a part of the aesthetic dimension we can begin to imagine new approaches to aesthetics and affective instances through the production of novelty through inducing any number of relations or interactions.

Morton devotes substantial attention to examining relations between objects and he asserts that any means by which we perceive and access other entities (objects) through sight, touch, sound, thoughts etc. are all fundamental to reality. There is a particularly compelling argument he makes in regards to aesthetics, stating, “It might be better to think of a transfer of information – it might be better to think that causality is an aesthetic process” (2013). If we take aesthetics to be a fundamental feature of reality and intimately bound with causality (Morton, 2013) then computational systems are just as capable if not more, at accessing the “real”. The flat ontological designation he assigns to information, intimates that data has a particularly unique role in that it can manufacture and enable the proliferation of novel interactions between any manner of entities both real and imagined. In this way computational or artificial approaches may operate around the aesthetic in less mediated and by extension more accidental ways. So a computation that engages irrationality, that is not seeking to mimic or please but rather one which is looking for and is capable of generating novelty in interpretation, representation and translation may produce far superior aesthetic encounters. Hegel stated that, “Art has at its command not only the whole wealth of natural formations in their manifold and variegated appearance; but in addition the creative imagination has power to launch out beyond them *inexhaustibly* in production of its own” (1979). The computationally creative imagination has the power to launch *inexhaustibly* beyond. Most human aesthetic production involves the recognition, selection, filtering and re-presentation of phenomena. Computational entities are also capable of these tasks and can be thought of as possessing more of an inclination towards the accidental rather than less. The potential for these systems to surprise us and present us with novel results is incredibly underappreciated.

The implication that chance or randomness is entwined with creativity is not a new insight. Hoffstadter in *Gödel, Escher, Bach*, explained, “it is a common notion that randomness is an indispensable ingredient of creative acts. This may be true, but it does not have any bearing on the mechanizability – or rather programmability! – of creativity” (1979). But conventional designations of the aesthetic and by association creativity rely on an observer. The human is able to recognize, appreciate and locate aesthetic qualities and outcomes and even program these capabilities artificially. But these activities have still been interpreted in fairly conventional terms. A new metaphysical approach to aesthetics seeks to step outside of the rift or gap that eludes description. Rather than any sort of clear distinction or description, a focus instead on the pervasiveness of the accidental as a fundamental

feature of reality allows us to begin to reformulate our conceptions of artificial aesthetics and instead look towards the ability to generate a multiplicity of novel interactions of varying spatio-temporal specificities.

Speculating upon aesthetics is but one approach by which we may engage future computational ecologies. Their speeds, specificities and interactions could easily be unrecognizable to us. Their rapidly proliferating complexity produces an opacity in relation to exact processes or methods of generating information and relations. The accidental or provisional should not preclude us from recognizing the vast potential these systems have for generating novel relations. The expectation of complete comprehension is not in place for the variety of other numerous entities we interact with daily, or even ourselves for that matter. Opacity is a persistent feature of our experiences. We might begin by acknowledging that our current approaches to aesthetics whether through metaphysical analysis or creative practice may be highly limiting. Computational systems, with their ever expanding abilities, relationships and entanglements may offer untold potentials to affect and be affected in unrecognizable, accidental and yet highly aesthetic ways. By reframing the ways in which we designate, produce and assess the aesthetic we can begin to engage the synthetic, the accidental and the computational in wholly novel ways both philosophically and creatively.

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Training Performing Artists in the Digital Age: The Performance and Interactive Media Arts Program as a Model

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Keywords: PIMA, performance, interactive media arts, MFA training, arts collaboration, digital media, interdisciplinary arts, art and social engagement, Brooklyn College, Guy Debord, *dérive*.

The paper examines the changing culture of the arts in the digital age as the parameters of the artist expand, demanding diverse skills, flexibility, and an entrepreneurial outlook, focusing on how that impacts the training of the artist in an increasingly interdisciplinary, collaborative, technological, socially engaged environment, including a model for training the interdisciplinary performance artist employing digital media and engaging in community collaborations, the Performance and Interactive Media Arts Program at Brooklyn College. <http://wp.pima-mfa.info>

The parameters for the artist in the digital age are expanding rapidly as media becomes an important part of the artist's canvas and an intermediary in the artist's communication with the audience. This opening of parameters is not only due to the presence of computer generated art, which allows for a myriad of interactive environmental experiences, but also due to the reconfiguration of what performance and art signify in our time. Art has gone through many articulations throughout history from being part of the social culture in the form of ritual or religious expression to the cult of the superstar artist provided with extensive access to the public via private, commercial, or state sponsored patronage.

With the increasing accumulation of individual wealth in society and the establishment of private patronage and investment in the arts, the artist's appeal has been tied to a network of patrons and the potential of their art to accrue value in the marketplace because of its unique qualities that are valued by the arts establishment.

Students of the arts have sought instruction at schools or with established artists that they hope will serve as an entrée to the art establishment, with the hope that this training will develop their unique talents and lead to the recognition of their particular genius. Museums, theaters and concert halls have become star makers offering certain artist ongoing public exposure. Artists create art specifically for galleries, large theatre spaces, and the concert hall, in order to become enshrined in the private and public sphere as reflections of contemporary tastes and values, whether as purveyors of the status quo or manifestations of radical chic.

Film, still and moving, has offered the possibility of greater exposure to a larger audience, allowing art to become ubiquitous through infinite reproduction, making it available to as many people as the market will bear, accelerating the migration of the arts into the populist sphere, where art has become entertainment, evoking the pleasure associated with both beauty and shock value. Filmmaking and theatrical enterprises put emphasis on the collaborative process between diverse artists, which encourages cooperation and specialization. In the sixties, with the introduction of portable video cameras and Super 8, filmmaking became accessible to the general public. As well, mixed-media experimentations and group happenings of Dada and other modernist movements in the early 20th century, along with the ideas of immersive theatre proposed by Antonin Artaud, began to change the focus of art from the notion of the singular genius artist, prevalent between the Renaissance and Romantic eras, to the artist who bypassed the patron in order to experiment and

interact directly with the public, finding their genius and support within group endeavors.

For a time both the genius artist and the collective arts groups have cohabited, but as technique becomes more accessible to the masses and innovation can happen in any corner of the world, individual expertise has become reliant on group input and the internet, a speedy conduit for information sharing, has facilitated networking. Photography, which relies on technology and the ability to edit and construct, rather than skills built up over years of drawing and work with the brush or chisel, has usurped the classical emphasis on portraiture and landscape, freeing the artist to mix techniques and themes with the emphasis now on conceptual originality. The same is true for theatre makers, or storytellers, who, faced with the impossibility of creating yet another original story, or competing with the impact of documentary films, are now focused on telling stories in a unique way. This new original approach is often facilitated by group endeavors and the television and film world rely on a stable of writers, with diverse abilities, to turn out a script. Art students now explore a plethora of techniques through the various offerings possible in university settings, while the critical response, both in the classroom and in the art world, focuses on the ideas behind the work, with technique becoming more and more taken for granted as a facilitator of concept.

With the introduction of digital techniques and the interactivity of the internet and the growing availability of instruments of creation to the masses, the emphasis on genius as a property of the few has changed into the idea that everyone has the possibility of expressing their own particular genius. As well the dramatic change from a male to a female dominated educational culture, beginning particularly in the earlier grades, has changed the value system of youth from a competitive individualistic approach to a culture increasingly geared towards collaboration, sharing, and enabling in which the classroom becomes less and less stratified while the teacher becomes a facilitator rather than an authority figure. This has had a tremendous effect on the interests and preferences of younger artists who in general no longer carry the image of the romantic isolated artist but rather the socially engaged art maker working in collaboration with their community and facilitating the creative impulses of others.

The digital age and the internet has created a forum that promotes open access, which puts it in a dialectic with established institutions promoting art that is juried by “experts” and insiders. Though Museums and performance venues have expanded their public spaces and in some cases have become cultural shopping malls – one can walk through the MoMA and see a performance or

two as one goes up the staircase to view a myriad of galleries and special entry exhibits, as well as checking out three or four different bookstores, selling all sorts of luxury items, and eat at several different areas within the museums – these museums can only serve a fraction of the working artists seeking public exposure. A redefinition of art venues and communities and an expansion of arts interactions with the audience has provided the artist with the possibility of developing a career outside the establishment. And the internet, with its vast access to the public, has greatly facilitated this. Young artists augment their access to audiences through inclusionary tactics from social media to collaboration with other arts groups. As well young audiences often find non-traditional venues friendlier, less elitist, and more socially enabling, which are also more cost effective for the artists.

France, where there is a tradition of the week-end artist, and the informed amateur, has been instrumental in expanding the notion of the artist, the audience, and the venue. The poet Baudelaire articulated the idea of the *flâneur*, the artist-spectator of the modern urban landscape, who leaves the isolation of the studio and “enters into the crowd as if it were an immense reservoir of electrical energy” (Baudelaire, 9) strolling through the city with an aesthetic pleasure, passionately engaged, yet incognito. The *flâneur*, is both reader and artist as his/her observations determine the art. This notion evolved with the Dadaists and Surrealists who took a more active approach using chance to establish a relationship with the street by following certain arbitrary signposts. Marcel Duchamp turned the *flâneur* into an establishment artist by bringing found objects of the urban landscape into the museum. The Situationists took the *Flâneur* a step further by suggesting a conscientious analysis of urban geography and its distinct attractions (Debord). The artist no longer needed to access a traditional venue, they could now use the urban landscape as their studio and stage.

This opening up of artistic practices, pulling the artist out of his private preoccupations into social engagement, collaborative endeavors, and expansion of techniques, has taken over a century. The ubiquitous urbanization of the landscape, the easy access to a virtual global crowd, 24-7, and the plethora of accessible creative tools has changed the artistic landscape irrevocably. The question becomes how to prepare the emerging artist for this new territory. Most models of arts education still focus on the creation of the individual genius, providing an education that banks on the artist succeeding through a unique aesthetic achievement that sets them above the rest, though the odds are remote for most artists, even those of exceptional talent. The market place is volatile and the public interest quick to change. In a world full of

entrepreneurial artists, those who focus on their own particular genius, in isolation, will generally stay there. Today the working artist is in general flexible, crosses styles and disciplines, spends as much time networking as creating, and often has an easier time getting funding for collaborative, interdisciplinary work, integrating technology, and including social engagement. Using social media and building an image through industry standard promotion is also important. Most importantly is the ability to conceptualize how these diverse potentialities can come together to articulate a single vision. However there are few arts education programs that offer a training that encourages all these qualities.

Ten years ago several Brooklyn College faculty began to imagine a graduate program, Performance and Interactive Media Arts (PIMA <http://wp.pima-mfa.info>), based around interdisciplinary practices in which collaboration, performance, and interactive media would be a core part of the training. It brings together theater makers, musicians, dancers, sound artists, visual artists, software programmers, poets, etc.. All projects in PIMA are created collaboratively. In the first semester, students are given general assignments, with a loose set of objectives to provide a focus towards creating weekly collaboratively generated performance projects, approximately ten minutes in length, as well as longer end of semester projects. Collaborative group members rotate weekly in order for class members to work with everyone in different combinations. Feed-back is ideally conducted under a framework developed by dancer Liz Lehrman, in the 1990s, in which the point of the feed-back is to support the goals of the group and avoid critical responses that impose an external vision. In the second semester projects become semester long endeavors and are usually performed off campus.

PIMA students are introduced to Max/MSP software in their first semester, integrating the technology into their weekly creative work. During the course of study, the training seeks to introduce various softwares and digital tools such as Arduino, Adobe Creative Suite, Protocols, Projection Mapping, Isadora, Processing, Abelton, and Audacity, with the goal of giving students a large digital palette from which to work. As well, everyone is required to do physical training towards attaining performance skills, with an emphasis on Viewpoints, a method that fosters collaborative dynamics and an awareness of the demands of composition and dramaturgy as part of the creative process. PIMA students are expected to be ready to be of service to each other in setting up projects for viewing and take-down. A spirit of collegueship and mutual support is necessary for the successful realization of the program. A core course, often pivotal in terms of a PIMA student's evolution within the program, is the PIMA course on social

engagement in the second semester, in which students work with communities outside the college with the goal of creating an event that reflects an authentic collaboration between community and artist. PIMA training includes a knowledge of the contemporary history of performance and theories associated with a deeper understanding of 21st century performance techniques, as well as effective practices in creating collaborative community actions, and theory often informs concept and process. There are also courses in pedagogy, as well as self-producing.

The year long thesis in the second year must be done off campus and the students take responsibility for all aspects from creation to finding a venue, fundraising, enlisting outside collaborators as necessary, and publicity. The collaborative approach to creating performance breaks with many of the expectations set up by the professional theater, which include defined roles, specialization, and individual credit for work done. Having no designated director to navigate the creative process, each member of a PIMA cohort is expected to take on the responsibilities of that role, sharing in the leadership of a project. Hierarchy is avoided and flexibility is encouraged. Everyone takes on the responsibilities of conceptualization and realization, including the roles of producer, designer, and performer. One of the challenges of a collaborative process is the continual communication demanded of its participants and technology is enlisted in facilitating discussion, with online conferences and idea sharing.

In this structure, individual ownership of ideas is harder to establish as discussions are not about who did what but more focused on the how and why of the project content. This free-wheeling creative process translates into events where participants and audience interact directly, as well as through technology, including using cell phones in various creative ways or triggering interactive sound and video installations. Immersive actions or Situationist *dérive* encounters with the urban landscape are also incorporated providing controlled and spontaneous audience participation.

As to professionalization and the job market, there is no specific career expectation in the program, knowing that the artist of the future will have to be flexible as the expectations and interests of a new generation of spectators change at an increasingly rapid rate: social, aesthetic, conceptual, producing, pedagogical, and technological skills, provide the graduates the ability to enter a variety of professional activities in the arts from performance making and digital design to producing, curating, scholarship, social engagement, and teaching.

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Fluid Control: Media Evolution in Water

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Keywords: controller, computer interface, water, electronic music, video, mass inertia, fluid, potentiometer, switch, fader

We have developed water based electronic elements which we built into electric circuits to control different parameters of electronic sound and video tools. As a result of our research we have constructed a complex controller whose main component is water. This tool makes it possible to control analog and software synthesizers as well as video software and other electronic devices, especially microcontroller based platforms like Arduino or Raspberry.

Introduction

Many traditional music instruments such as violins, guitars, timpani, pianos, and trumpets can give the musicians an immediate tactile response to their play. A strike on the timpani makes the mallets bounce back in a very specific manner, depending on the velocity, intensity, point, and angle of the beat. Plucking a guitar string, bowing a violin, sounding a trumpet or pushing a key on the piano not only requires overcoming a resistance but it also produces a kickback. On a piano for example, this kickback consists of the hammer falling back, an effect which the musician, upon touching the keys, can feel directly in his fingers. The nature and strength of this kickback response depend on both, the type of the action (plugging, beating, blowing, striking), and the strength, the sound quality, the pitch.

In electronic music the tactile feeling of the generated sound is absent. We cannot grab into the electric power and influence the sound quality with our hands in a direct manner. We cannot feel the swinging of an oscillating electric circuit consisting of transistors, resistors, and capacitors. Musicians have to play electronic instruments always in an indirect manner via interfaces.

These days the development of many industrially produced interfaces tends to avoid mechanical components as much as possible or to use only a minimum of mechanical parts. This leads to the fact that the input devices themselves do not create any music adequate resistance against the musician's acting. Moving a fader or potentiometer from point zero up to half (50%) requires the same force as moving it from half to the top (100%). If this tool is used to influence the volume or the amount of distortion of a sound, one would wish for a fader whose sanding resistance increases according to the distance. Certain attempts have been made at finding a solution but the results have not yet gone beyond the status of a dummy, i.e. they are not actually included in the work circle of the sound production.

The best known example of such a development are the weighted keys of a keyboard. They are supposed to imitate the feel of a traditional piano but are not actually linked to the sound production. However, these particularities of the electronic sound generation do not imply a lack because the listener is rewarded with an immense amount of sound possibilities, a wealth that hardly exists in music produced with traditional instruments. On the other hand we have to admit that these particularities clearly influence the aesthetic perception of the work. Especially in the beginning of electronic music people used to describe the sound as very mechanical.

Fluid Control

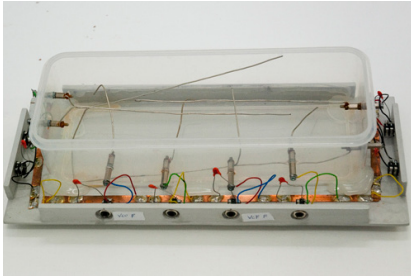


Fig. 1

The artist group “wechselstrom” has made an attempt to develop the potential: A first approach consisted of producing the movement of sounds in space with an interface that gives the musician a physically tangible reference to his actions. These movements are normally regulated with a pan knob or a joystick. We equipped the interior of a closable plastic box with metal wires that took over the function of inputs and outputs of a mixer. These wires were isolated from each other, i.e. they hung free-floating inside the plastic box (Fig. 1).

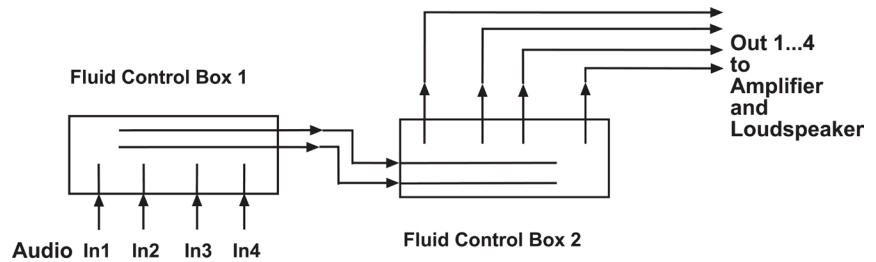
The moment when the box was filled with (tap) water a complex structure of potentiometers was created mutually influencing each other. The wires took over the function of electrodes and the water served as a variable resistor. Measurements showed that the electrical resistance between two electrodes was between 15 – 50 kohms, depending on the immersion depth and the degree of wetting. These values are also used in normal potentiometers in electric circuits.

We have called this new instrument the “Fluid Control” box. It has been our goal to use Fluid Control as a matrix mixer which combines the functions of controllers, switches, faders, panning regulators, and joysticks in one hand. The movement of the water inside the box, the sloshing of the liquid reveals not just an audible image of the movement of sounds in space. Furthermore, the player / musician can bring his own body into a tactile relationship with the shifting weight of the water. The body and the instrument can now get into a resonant interaction. This process is similar to the rhythms of a sand- or rice-filled egg shaker which sound most lively when one succeeds to synchronize the movement of the grains with the swinging movements of the hand and arm.

In summer 2012 (during the festival Sound Barrier) we set up two Fluid Control boxes, two CD players, which resulted in a total of four mono tracks, and a 4-channel sound system. The four mono tracks coming from two CD players were launched into the input side of the first Fluid Control box mixed together with the appropriate proportion of water and sound levels on two tracks. This mixture was fed into the second Fluid Control box and distributed dynamically to the four channels of the sound system (Fig. 2).

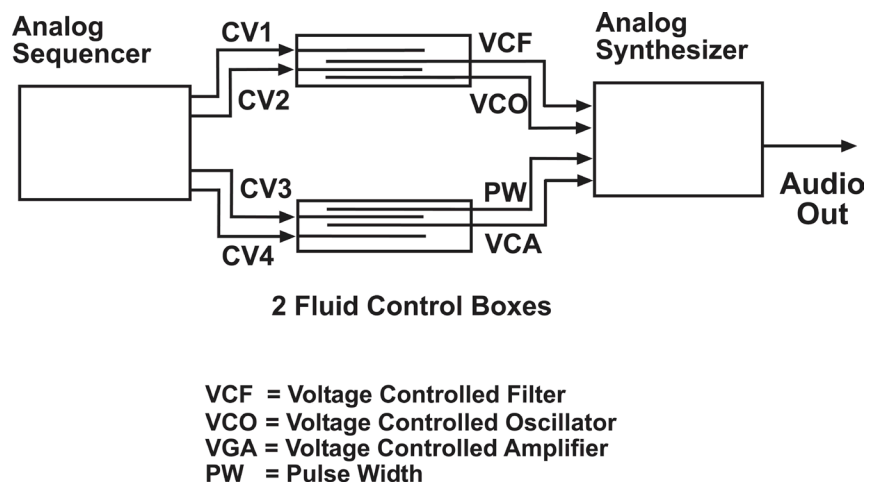
Following the golden rule “current is current is current” the next step was to modulate not only audio signals but also to modulate control voltages generated in analog synthesizers. These electronic devices have the advantage of providing multiple physical inputs and outputs that can be plugged in directly. We

Fig. 2



showed this second setting for the first time on Sept 15th 2012 in the Jazzschmiede in Düsseldorf. We used the possibilities offered by Fluid Control for influencing the control current that was produced by an analog sequencer in order to drive an analog synthesizer (Fig. 3).

Fig. 3



As a result of our research we have created a tool which makes it possible to control electronic sounds within the dispositive of preselected sequencer and synthesizer setups in a very fast, dizzy, sophisticated, and sometimes chaotic way. Developing this tool we intended to make the change of the sound parameters in electronic music physically tangible. We also wanted to give the player a resistor / a weight into his hand which enables him to react in a more immediate and body conscious way to changes in sound beyond the scope of what controllers and interfaces like buttons, faders, rotary potentiometers, and touch screens can do.

As a the third we wanted to bring Fluid Control into the sphere of the digital wold of computers, software synthesizers and, as a follow up, of video or any other multimedia software. All well-known software synthesizers like MAX, pd, Reaktor etc. and most video/graphic software (MAX/jitter, Resolume) use and understand MIDI specification to control various parameters. We used a MIDI box which provided MIDI inputs and outputs and was connected via USB or FireWire to the computer on the other side at the same time. For the creation of a reliable MIDI data stream we took

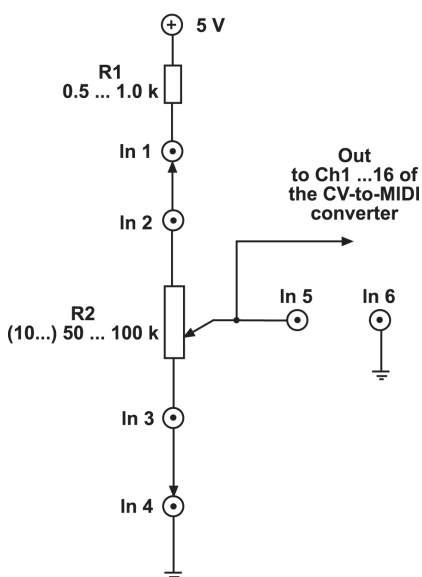


Fig. 4



Fig. 5

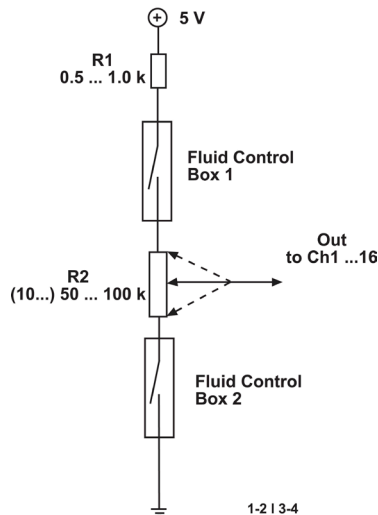


Fig. 6

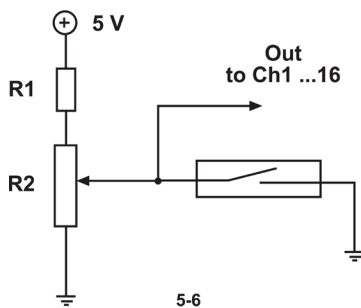


Fig. 7

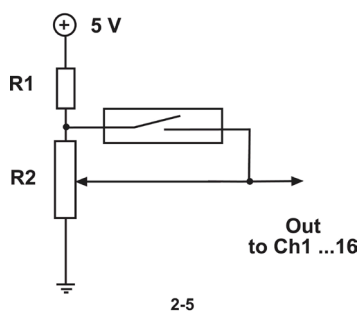


Fig. 8

the +5 volt CV (Control Voltage) specification as an equivalent for the midi data value 0...127. We generated the corresponding data stream via a CV-to-MIDI converter. We modified the control voltage, which is often constructed with a single potentiometer, by adding the Fluid Control Box and by building it pre-, and/or post-fader or as a side channel into the electric circuit (Fig. 4).

“In1” and “In4” (socket symbol with arrow) are sockets with switching contacts, all other sockets are without switch. R1 is a resistor preventing a short circuit when sockets are connected in a wrong way (e.g. if you connect In1 to In6). The out goes to the input of one of the 16 channels provided by the CV-to-MIDI converter, which means that this circuit diagram was built 16 times (Fig. 5).

Connections can be made between all sockets, even between sockets of different channels. However, only the following connections produce an effect: In1-In2, In1-In5, In2-In5, In3-In4, In3-In5, In4-In5 and In5-In6.

Fig.6, 7, and 8 show the basic connections. In Fig.6 two Fluid Control boxes are looped in. Together with R2 they build a voltage divider. When the slider of R2 is in the upper position the first Fluid Control box has more influence than box nr.2 and vice versa. When for instance the second box is plugged out the remaining box achieves the highest effect with the slider of R2 being in the upper position. When the slider is in the down position the box is inactive because the slider is connected to ground, therefore the output voltage is zero. In Fig.7 and Fig.8 the box achieves its highest efficiency when the slider is in the center position.

Obviously, Fluid Control can be connected to any microcontroller or computer. In this case a MIDI-translation is not necessary, the circuits shown in Fig.4 – Fig.8 can be directly plugged into the analog inputs of the Arduino or Raspberry.

Film clips illustrating the operation of this instrument are available under the following Internet links:

How it works: (search for “Fluid Control Essenz”) <https://www.youtube.com/watch?v=ed4JlMMNnyg> and “Fluid Control – The Installation” <https://www.youtube.com/watch?v=41uZi7bEdeI>

wechselstrom

Christoph Theiler & Renate Pittroff

“wechselstrom” is a label owned by Renate Pittroff and Christoph Theiler. Based in Vienna, “wechselstrom” runs a so-called “off-space”, which offers room for exhibitions, media activism and all art forms on the fringe of culture.

Selected works:

Piefkedenkmal – the construction of a monument for the musician Gottfried Piefke, who is also the namesake of the well-known Austrian derogatory name for Germans (2009 Gänserndorf)

Samenschleuder – a tool for environmentally conscious car driving (2009 Weinviertel, Lower Austria)

bm:dna – the government department for dna-analysis (2005 Vienna)

Tracker Dog – follow a (your) dog and track the route with a GPS, then print and distribute new walking maps (2008 Mostviertel, Lower Austria)

Community Game – a tool for distributing government grants using a mixed system of democratic vote and randomized control (2006 Vienna – distributing 125.000 Euro)

whispering bones – a theatre play asking for the whereabouts of A. Hitler's bones (2004 Vienna, rta-wind-channel)

Reply – mailing action: resending Mozart's begging letters under our own name to 270 people: to the 100 richest Germans and Austrians, to managers and artists of the classical music business, and all members of the Austrian government (2005/06 Vienna)

Re-Entry: Life in the Petri Dish-Opera for Oldenburg 2010

www.wechsel-strom.net, www.piefkedenkmal.at

www.samenschleuder.net, www.trackerdog.at



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Designing with Biological Generative Systems: Choice by Emotion

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Keywords: biological design, generative, customization, emotion

Consumers as co-producers or co-designers are frequently presented as the solution for mass-*customization*, but the success of these systems as enhancing emotional bonds between user and object seems to be questionable. Making choices may not be enough to generate a bigger connection between people and their things. Artifacts produced using biological systems with generative potential, where nature's randomness and physiological processes have an important role in the definition of form, may have the capacity to foster the emotional connections that are missing, arising from nurturing and from an understanding of their morphogenesis, from the proximity and time required for their growth and development.

1 Introduction

More than thirty years ago Alvin Toffler in *The Third Wave* (1980) projected that the consumer would be integrated into the production process and that goods and services would be self-customized to a point where consumption and production would be intertwined as one. He called this producer-consumer a *prosumer*. It seems like Toffler wasn't completely wrong, as we see many companies shaping their business plans to integrate users into their design and production processes (Piller, 2004), but he wasn't also completely right.

In *The Paradox of Choice*, Barry Schwartz points out that the lack of success of these systems based on *co-production* or *co-design* resides mainly on the fact that consumers don't know or don't want to make choices: "As the number of choices grows further, the negatives escalate until we become overloaded. At this point, choice no longer liberates, but debilitates. It might even be said to tyrannize." (2005). This is where mass-customization may lead to "*mass confusion*" (Teresko, 1994) due to great uncertainty and the burden of choice. (Piller, 2004)

Digital generative systems may be part of the solution, their capacity to produce new designs automatically, modifying one form into another with algorithms guarantying a unique outcome each time; this means that with one single choice – when to interrupt the process – the consumer obtains a one-of-a-kind product.

Although we can see great potential in digital fabrication (mainly additive manufacturing) for the production of complex, unique and innovative artifacts, as the technology presents itself today, it has many limitations when compared to production with standard manufacturing methods, not guaranteeing the quality one can expect in a consumer good (Grimm, 2012).

In biological systems with generative potential, where nature's randomness and physiological processes have an important role in the definition of form, we understand that artifacts have the capacity to foster emotional connections that arise from their nurturing and from an understanding of their morphogenesis, from the proximity and time required for their growth and development. Choice in this scenario may not be a burden but rather a pleasurable action like feeding a pet or watering a plant.

These systems seek to develop artifacts in a *sprouting* stage as well as the constraints for their *growth*. Artifacts resulting from these processes are the result of a close relationship between the various constituent elements, as the system will only outcome in a final product if it is understood and nourished. The end result is singular and unique, with aesthetic qualities that arise from the understanding of the artifact and the connection created with

it. In this context, there artifacts are *individualized*, more than *customized*.

We are developing a series of DIY matrices for the production of artifacts made with mycelia (the vegetative part of a fungus, consisting of a network of fine white filaments) in an embryonic stage, to be distributed to users that will be asked to nurture them into final objects; in this process each user will *nurture* their artifact into a *final* object, where all options will be of their responsibility, from sunlight exposure to interruption of growth. To better understand how individuals respond to this type of objects and to the choice making, each user will be requested to register the daily evolution of their artifact and to describe their feelings towards it.

2 Context

In *The Meaning of Things, Domestic Symbols and the Self*, Mihaly Csíkszentmihályi and Eugene Rochberg-Halton, affirm that to most people, plants are one of the most cherished possessions in the household. They defend that this happens due to the “slow, growth-producing nurturance and life-giving concern”, we can also add that because a plant is a living thing with an *existence* of its own, we tend to look at it differently than we do to inanimate objects (1981). Bruce Sterling in *Shaping Things* forecasts a near future where humans and objects are part of “comprehensive and interdependent” systems, in a “*technosocial*” culture (2005).

Biological systems that are generative or have generative potential can produce artifacts that provoke new ways of relating to our things, questioning the standardization seen in mass production, as stated by Deyan Sudjic in *The Language of Things*: “the role of the designer when working for the industry is more than the one who conceives the form of things, it is to think out the interaction between people and the artificial world, and in particular how we become attached or not to things”(2009).

Projects like *Veiled Lady* by Studio Eric Klarenbeek and *Silk Pavillion* by the MIT Media Lab are examples of how objects can evolve from an embryonic stage into complex unique artifacts if they are nurtured and understood, and can reinforce the relationship between users and their things.

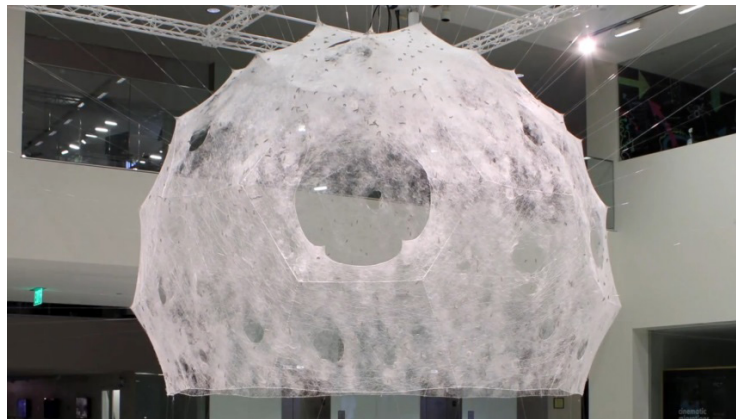
Veiled Lady is part of the *The Mycelium Project - Print and Grow*. Using a 3D printer with two independent extrusion nozzles, an inoculated straw based substrate was deposited inside bioplastic structures printed at the same time with the configuration of a bench and, after a few weeks it bloomed. The growth process was interrupted by dehydrating the mycelia resulting in a stable unique product (Klarenbeek, 2014).

Fig. 1 *Veiled Lady* by Studio Eric Klarenbeek © Studio Eric Klarenbeek 2014



In *Silk Pavillion*, A structure was made out of a silk thread laid down by a CNC (Computer-Numerically Controlled) machine. A swarm of 6,500 silkworms was positioned at the bottom rim of the structure, and autonomously reinforced the gaps across CNC-deposited silk fibers. Following their pupation stage the silkworms were removed (Oxman et al., 2013).

Fig. 2 *Silk Pavillion* by MIT Media Lab © Steven Keating 2013



3 Testing

A small series of DIY casts and step-by-step instructions will be distributed to allow people to build their own matrix and grow their own product with the intention of better understanding how individuals respond to these objects. The casts will consist of a STL (Stereo lithography) 3D printable format and a PDF drawing of the cutting dimensions for a plastic sheet. After being printed and cut, these materials are easily assembled and filled with mycelia inoculated straw. To ease the users' job we recommend the transfer of the content of a commercial mushroom kit into the predefined form. Dimensions will be constrained by the printing volume of an average low-cost 3D printer, and the initial user group will be

selected among people with some experience with commercial mushroom growing kits. The choice of this user group guarantees some familiarity with the nurturing process and can give us an emotional comparison between a traditional commercial kit with the only focus on producing edible mushrooms and the possibility of giving the substrate a second use.

Each user will be asked to nurture their artifact into a final object, and for this they will have to follow the normal instructions of the familiar commercial kit. All options will be of their responsibility: sunlight exposure, room temperature, when and how much to water, growth interruption, etc.. Each user will be asked to make a log of their options and a photographic register of the mycelia's expansion and mushroom growth and a questioner will be used to understand their feelings towards it the various stages.

Natural forms are continually modified during growth by their surroundings. Theoretically all the leaves of a single tree should be identical, but this could only happen if they were able to grow in surroundings completely devoid of outside influences and variations. All oranges should have an identical round shape. But in reality one grows in the shade and another in the sun, another in a narrow space between two branches, and they all turn out to be different. This diversity is a sign of life as it is actually lived. The internal structures adapt themselves and give birth to many diverse forms, all of the same family but different (Munari, 2008:167).

The system and the initial template will be designed, leaving most of the growth constraint choices for the user. We believe that a greater awareness that their actions helped define the final object, will also generate a greater tie-in between user and object, a connection by emotion and understanding more than the mere relationship of possession.

In the presented case, the filing of the cast results in a hollow conical geometry that can be used as a suspending lamp shade, we understand that proposing an artifact that can have some kind of utility will help the users to easier relate to it and will facilitate their ability to question its aesthetic qualities by having the possibility to compare the object to a well-known, common product. The option of designing an artifact with a simple geometry has the intent that the growth of the mushrooms will have a bigger emphasis in the overall aspect.

We understand that the outcome of these systems may not be perceived as having the traditional attributes that are connoted with quality products, one has to be connected to the artifact by

the whole understanding of the process and not only simply by looking at its surface. As Donald Norman explains:

Attractiveness is a visceral-level phenomenon – the response is entirely to the surface look of an object. Beauty comes from the reflective level. Beauty looks below the surface. Beauty comes from conscious reflection and experience. It is influenced by knowledge, learning and culture. Objects that are unattractive on the surface can give pleasure. Discordant music, for example, can be beautiful. Ugly art can be beautiful (2004:98).

The problem is that we still let logic make decisions for us, even though our emotions are telling us otherwise. Business has come to be ruled by logical, rational decision makers, by business models and accountants, with no room for emotion. Pity! (2004:21)

By comparing the questioners we aim to be able to better understand if and how the emotional connection evolved between user and object, the daily photographic register may offer a better understanding on how the base geometry *evolved* into its final form and what factors motivated the variations.

We intend that before the end of March 2015 the user group will be defined and briefed to initiate the experimentation with the proposed templates, if we consider the average growth rhythm of the mushrooms, the final results should be ready before May 2015, giving us time to analyse the data before June 2015.

4 Conclusion

In systems that rely on the consumer as a *co-producer* or *co-designer*, the way choice making is forced on them can be a problem, and does not guarantee a greater empathy between a person and their objects. To achieve artifacts that are traded in an embryonic stage and that rely on a biological actuator with generative potential to produce unique individualized outcomes, but at the same time, are dependent on the user for their evolution and final conformation is one of the expected results.

In the same way we can say that when a plant grows it is also responding to its grower, and that this creates unique bonds that are different from those common between people and their inanimate things. We look forward to the idea that these systems will catalyze greater empathy between objects and their users although they are not living artifacts themselves but the result of a living system.

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Objects with Multiple Sonic Affordances to Explore Gestural Interactions

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Keywords: design, sound synthesis, interaction.

We present a family of sonic interactive objects called Stonic. They are designed to provide users with different affordances, i.e. action possibilities, associated to specific sound feedback. These objects are used in experimental studies to explore how augmented auditory feedback influences the object manipulation. We selected a set of basic interactions based on studies on the auditory perception of physical interactions producing sound. These interactions correspond to different ways of manipulating the objects, leading to a set of design requirements. Twenty initial objects were made with acrylic resin and/or polystyrene. Each different shape was tested in order to select a smaller number of objects affording a wide variety of actions. The selected shape were finalized using 3D printing and equipped with several sensors: Force-Sensing resistor (FSR), Piezos and an Inertial Measurement Unit. Specific software was made to enable real-time recognition of the different interactions and for the mapping of each actions to specific sound processes.

1 Introduction

The development of interactive devices has challenged the traditional design approaches, by extending the concept of product usability to the user experience concept, which includes user's personal goals, expectations and emotional aspects (Pucillo and Cascini, 2014).

Our interaction with physical objects is multimodal by engaging not only the vision, but also touch, proprioception and sounds, leading to a holistic experience. We are particularly interested in the sonic aspects of the interaction that has generally been less addressed. Namely, our research is part of the emerging field called Sonic Interaction Design (Franinovic and Serafin, 2013) that focuses on the design of sonic feedback, taking into account the user-system relationships from an active and dynamic point of view. One objective of sonic interaction design is to extend the use of interactive object with sounds to achieve a variety of do-goals and be-goals through different motor-goals (Hassenzahl, 2013). In particular, we are interested here in designing the sonic interaction produced by the manipulation of objects, by augmenting them through sensors and sound synthesis. This implies modeling the different interactions between the user, the object and its environment.

Designers and researchers developed numerous examples of interactive sonic objects, dedicated to experiments (design and/or artistic). These objects have been also designed to study the impact of continuous sound feedback on different aspects of the user experience: from performance to learning, taking both emotional and aesthetic dimensions. However, these objects generally focused only on one or few basic gesture interactions. For example, the Ballancer (Rath and Rocchesso 2005) allows the user to tilt a wooden fence producing a sound linked to this simple action. Other researchers (O'Modhain and Essl, 2004) investigated the interaction between sound and touch through different prototypes: the Pebble Box (manipulation of stones) and the Crumble-Bag (crumbling action). The Spinotron (Lemaitre et al., 2009) is an object with a pumping action affordance. Clicking sounds generated by a physical impact model simulates the rotation of a virtual gear inside it. While these different objects can be used with a limited action set, we intend here to develop objects that afford a variety of gesture interactions and sonic feedback, i.e. offering different motor-goals. With this goal in mind, we designed manipulable *sonic interactive objects*, called, *Stonic*, augmented with sensors driving sound synthesis.

While sharing similar technological aspects, this research can be distinguished from most of the objects and interfaces developed

in the field of New Interfaces for Musical Expression (NIME). The aim here is not to produce a specifically sound or musical expressive results, but rather to focus on the object manipulation: we are interested to studying how the interactive sound design can inform and influence the object manipulation. Our objects are thus designed to investigate how the action-sound relationship (arbitrary, metaphorical, analogical) can influence the manipulation of the object, and how the different types of morphological sound characteristics can influence the user agency, i.e. producing the sense the user is “in control” of the sound they produce (Knoblich and Repp, 2009).

The paper is structured as follows. We introduce the theoretical bases that guided us in the design of the object’s shape and the possible interactions with this object. We present the hardware and software development.

2 Physical Interactions

The theoretical bases that have motivated the object design come from two different sources. The first one draws from studies on environmental sound perception and the second one corresponds to the literature on manual gestures.

The physical interactions producing sounds have interested researchers in order to understand the different mechanisms associated to sound perception. In the continuity of Gaver’s work (Gaver, 1993), we have studied the categorization of environmental sounds (Houix et al. , 2012). The results indicated a distinction between discrete solid interactions (e.g., impacts, multiple impacts) and continuous solid interactions (e.g., tearing, shaking, rubbing, ...). These different interactions are the basis of our requirements for the object design, since we are interested in the objects manipulations related to the sound production.

In another domain, Napier (Napier, 1956) has proposed taxonomy of manual gestures during object grasping that differentiates a gesture requiring power and another requiring precision. This framework allows us to analyze how people grasp objects and to relate these actions to sound production.

3 Requirements and Design

Our approach is to define gestures and actions that are relevant in the study of gesture-sound relationships. For this, we started with a set of basic gestures associated with the manipulation of the objects. We then designed appropriate shapes, and equipped some 3D printing versions of the objects with sensors.

3.1 Basic Gestures and Forms

We started with the lexicon that described different types of interactions producing sounds. The lexical analysis of sound categories (Houix et al, 2012) have shown a distinction between discrete interactions, like impacts or cyclic movements and continuous interactions like deformation (to crumple, to crush, to rub, to roll, ...). Actions like to crease or to crumple were excluded in this first study that was restricted to the interaction with solid object. We also removed actions such as cutting or to sawing which would require using tools. We finally selected ten actions: to hit, to rub, to roll, to turn, to swing, to put, to shake, to press, and to play with / to crush. These actions are directly related to lexicon of solid interaction categories (Houix et al, 2012). User can produce these actions directly by manipulating an object with one or two hands, in contact or not with a surface. These actions can imply low or high energy. The actions cover also the different hand manipulations (power & precision grasp, prehensile vs. non prehensile, motion of the hand or within the hand or no motion) that have been classified previously (Bullock, 2013). This repertoire of actions and conditions of manipulation constituted the basic requirements for the design of the shape. We started with twenty initial prototypes made with acrylic resin and / or Polystyrene (made at scale 1.0). Each object exhibits a different shape and different behaviors, for example offering swinging motion like Weeble¹. We made a first selection based on the specifications (Figure 1). We tested the different actions produced within the hand, on the object and the object in contact to the surface during an behavioral experiment in order to test the different affordances without sonic feedback.

Fig 1 The selected prototyped shapes and with their associated 3D print version (when available).



¹ <https://en.wikipedia.org/wiki/Weeble>

3.2 Hardware and Software

3D Print objects are built with a neutral material (ABS), and equipped with different sensors. The sensor data are processed in order to recognize the different interactions, and mapped to different sound synthesis systems. The electronic part is based on a Wifi module combined with a micro-controller, that follow-up of previous systems (Rasamimanana et al., 2011). The object contained an integrated 9 DOF inertial measurement unit (a triple-axis gyro, a triple-axis accelerometer and a triple-axis magnetometer) allows us to derive the absolute angles. These sensors give the absolute orientation of the gravity (up or down), the relative rotation speed and the acceleration (for example: shaking). The object contains also a force-sensitive-resistor (FSR) and two Piezo sensors that are connected to the main board through I2C using a Teensy 3.0 development board. The piezos allow us to capture rubbing or tapping and the FSR a gradual pressure. The sensor data are processed in order to differentiate the different actions, such as rubbing, tapping, shaking, ..., and to drive sound synthesis. The mapping strategies, combining both discrete and continuous strategies, are extensively based on machine learning methods that allow performing both recognition and mapping. Specifically, Multimodal Hidden Markov Models (MHMMs) are used to learn the mapping between movement features and sound synthesis parameters. The sound synthesis uses recorded sound material processed with granular synthesis and descriptor-driven corpus-based concatenative sound synthesis (Schnell et al, 2009), optionally complemented with physical models. The system is implemented in the Max6 environment (Cycling'74). We also use a method called "mapping by demonstration", by recording examples of actions performed synchronously with sound examples, and using interactive machine learning techniques. This allows to quickly prototype, experiment and adapt sonification strategies in the design process, and could allow users to craft themselves the sonic interaction without expert programming knowledge.

Summary and Perspectives

We present the design sonic interactive objects that provide affordances for different type of basic gestural interactions. We selected specific interactions that can be related to sounds produced by physical interactions. These experimental devices are equipped with different sensors allowing us to recognize these different interactions and mapped the sensor data to various sound processes. These objects will be used for evaluating the influence of

the sound feedback in object manipulation, as well as the change in the perception of the object affordances.

Supplemental materials are online:

<http://legos.ircam.fr/stonic/>.

We acknowledge support from the Legos project (ANR 11 BS02 012)

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The Maximum Score in Super Don Quix-ote

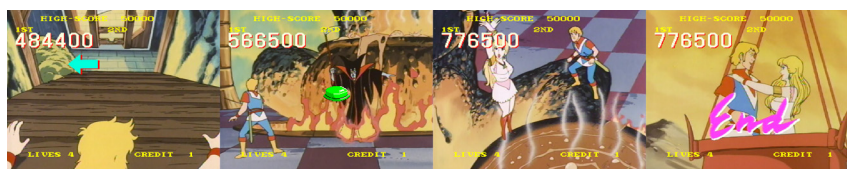
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Keywords: Videogames, Retrogaming, Laserdisc, Artificial
Intelligence, Computer Vision, Easter Eggs

Arcade laserdisc videogames were pioneered by the original 1983 release of Dragon's Lair from Advanced Microcomputer Systems. Alas, the punishing gameplay mechanics of Dragon's Lair left many players frustrated. The 1984 laserdisc game, Super Don Quix-ote, from Japanese developer Universal, continued to employ a traditional animation technique, while including on-screen prompts, providing the player with a helpful indication of the correct response to each challenge. By completing Super Don Quix-ote, without loss of life, a maximum score of 636500 can be achieved through routine gameplay bonus mechanisms. Super Don Quix-ote, however, also includes undocumented support for alternative responses to the on-screen prompts. In the project described here, the open-source Daphne laserdisc emulator; along with Super Don Quix-ote software including a binary ROM image of the game itself and associated video files; are provided as input to a computer vision system, proving a perfect score of 776500 is possible; then confirmed by the human hand. A video of the full playthrough is available at <https://youtu.be/ZpzWhfh92F4>, and submitted to the Twin Galaxies gaming records organisation.

Fig. 1 Climactic scenes from Super Don Quix-ote (1984) courtesy of the Daphne Laserdisc Emulator



1 Introduction

During the golden era of arcade videogames, from the late 1970s to the late 1980s, the graphical content of games was technically, and arguably artistically, superior to that provided by home entertainment systems. Barring exceptions such as *Battlezone* (1980), *Cube Quest* (1983), or *I, Robot* (1983), arcade games were constructed using 2D sprite-based raster graphics; with noteworthy examples from 1984 including *Pac-Land*, *Marble Madness* and *Kung-Fu Master*.

The 1983 appearance of the arcade laserdisc title *Dragon's Lair* presented a step-change in the visual quality of arcade games. A *Dragon's Lair* player is presented with what appears to be a traditionally animated cartoon. The catch is that the delightful animation will soon end abruptly in the avatar's death, unless the player takes singular action at *precisely* the moment intended by the game designer. Such intermittent moments of challenge in videogames would ultimately become known as quick time events (QTE); after the relative success of Sega's *Shenmue* in 1999. An alarming aspect of the seminal QTEs in *Dragon's Lair*, however, is that they are *not* accompanied by an on-screen prompt. Consequently, the player must instinctively, and frequently, respond to the subtle and fleeting dangers embedded within the game; by one of four moves from the joystick, or a press of the button.

Super Don Quix-ote (SDQ) was released in 1984, and its Japanese heritage can be discerned in the anime character design and animation; and to a comparable degree, by its cheesy and bombastic American dub localisation. The significant gameplay difference in SDQ, is that the QTEs are accompanied by an on-screen prompt; one of four rather jarring blue arrow icons, inviting an up, down, left or right movement of the joystick; or a green button icon, prompting depression of the sole physical button.

Gameplay is supported by a damsel in distress story theme, wherein the eponymous hero must rescue his lady love from a demonic witch. References to the 17th century Spanish novel by Miguel de Cervantes, *The Ingenious Gentleman Don Quixote of La Mancha*, are minimal: a young Quixote retains the squireship of Sancho (Panza) and his donkey (Dapple); with the ingénue addressed as Isabella rather than Dulcinea. A notable windmill appears towards the end of the game, replete with giant.

1.1 Gameplay and Scoring Details

Typically a player who fails to respond to a QTE, or who responds incorrectly, will see the action cut to a scene involving Quixote's death; accompanied by a decrement in the lives tally. If lives remain, gameplay will resume at the start of a level which has yet to be completed. An ad-hoc score bonus is awarded immediately after each successful QTE; and a player completing a level with no loss of life, is awarded the sum of the score bonuses from that level. Having completed the entire game, a final bonus is rewarded, equal to; where is the number of lives remaining.¹ A player completing the game without loss of life can achieve a score of 636500. This is, however, not the maximum score possible.

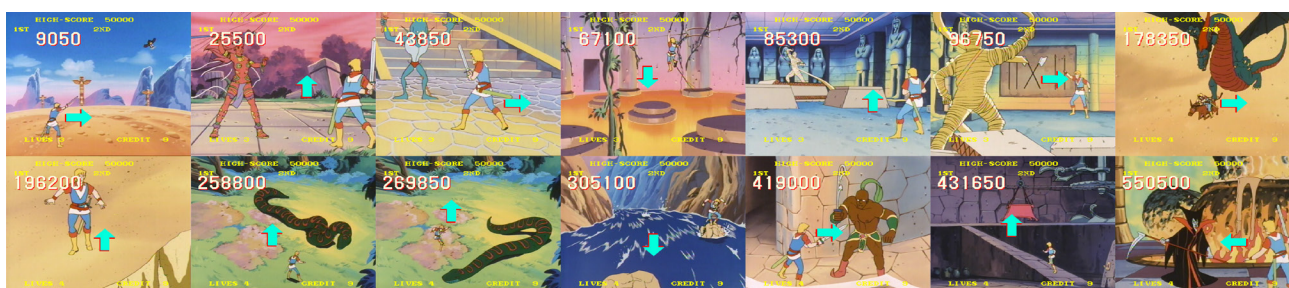


Fig. 2 The player is rewarded when using Button; Left; Button; Left; Left; Button; Down; Left; Left; Right; Left; Button; Left & Button (lexicographical ordering) instead of the on-screen prompts shown.

A selection of QTEs in SDQ allow responses distinct from those invited by the on-screen prompts. Figure 2 illustrates all fourteen such occasions. For example, the game's penultimate QTE prompt is shown bottom-right in Figure 2. An arrow invites a leftward movement of the joystick. Such a gesture is of course permitted; yet so is a *button press*. These 14 QTEs are sprinkled throughout the game, and each valid QTE alternate response provides the player an additional score bonus of 10,000. This project identifies *all* such QTE alternatives using custom software which exhaustively tries all possible responses to the 156 QTEs in SDQ. With this information, the game is subsequently completed by the author to obtain the maximum possible score in SDQ of 776500.

2 Software Development

To discover the full set of alternate QTE responses, an exhaustive automated search was planned. Two approaches then presented themselves: either modify the low-level source code of the Daphne (Ownby 2001) laserdisc emulator; or scan and analyse the display buffer using computer vision methods. With the source code for Daphne 32-bit, and the development system 64-bit Ubuntu, the first option was always on the back foot. The second approach was then selected; offering the attractive possibility to retarget software components towards other games or applications.

¹ An extra life is awarded when a score of 100,000 is achieved. Play starts with 3 lives by default.

Obtaining a handle to the display buffer of the relevant X Window on Ubuntu is simplified by the libxdo library; readily available in the package manager as libxdo-dev. As libxdo is a C library, the inclusion of the xdo.h header must be guarded by the extern “C” linkage specifier. Listing 1 need then only check that a single matching window was found; `list[0]` provides that window handle.

Listing 1 Code to locate an X Window named “DAPHNE:”

```
xdo_t *xdo = xdo_new(NULL);
Window *list;
unsigned nwindows;
xdo_search_t search;
memset(&search, 0, sizeof(xdo_search_t));
search.max_depth = -1;
search.require = xdo_search_t::SEARCH_ANY;
search.searchmask |= SEARCH_NAME;
search.winname = "DAPHNE:";
xdo_search_windows(xdo, &search, &list, &nwindows);
```

Having the Daphne emulator’s X window, the libX11 library is used to obtain its width, height, and screen coordinates. A further library from the package manager, Imlib2, facilitates straightforward interaction with the display buffer. Assuming `x`, `y`, `w` and `h` hold the size and location information, Listing 2 demonstrates code to obtain a pointer, `data`, to a contiguous array of 32-bit Alpha-Red-Green-Blue (ARGB) data; `DATA32`. It is also straightforward to save this as an image file.

Listing 2 Code to obtain fast access to the X display buffer

```
Imlib_Image img = imlib_create_image_from_drawable(0,x,y,w,h,1);
imlib_context_set_image(img);
DATA32 const *data = imlib_image_get_data_for_reading_only();
```

2.1 Recognising On-Screen Prompts

The QTE on-screen arrow prompts are not subtle; but usefully, are comprised largely of a single shade of blue. Using the minimal `grabc2` tool, a mouse click will reveal that its hexadecimal ARGB representation is `0xff00ffd8j3`; while the arrow’s red shadow is `0xfffd0100`. The four different QTE arrows can be recognised by traversal of the `data` array from Listing 2, looking for horizontal runs of blue pixels, followed by a shorter run of red; and vice versa. The green (`0xff00fe00`) on-screen button prompt is handled similarly.

² `Grabc` is also available from the Ubuntu package manager.

³ Different display drivers will generate different colour values.

2.2 Remote Control

With both the X window and a libxdo handle from Listing 1, commands to emulate the press and release of keys may be sent to the Daphne SDQ window as shown in Listing 3.

Listing 3 Example of code which emulates the press and release of the right arrow key

```
xdo_send_keysequence_window_down(xdo, list[0], "Right", 0);
std::this_thread::sleep_for(std::chrono::milliseconds(100));
xdo_send_keysequence_window_up(xdo, list[0], "Right", 0);
```

2.3 Knowing the Score

Alas, the score also requires comprehension. Analysis of the changing score can inform the algorithm as to whether an attempt at an alternate QTE response has been successful or not. An unchanging score can also evidence the loss of a life; and thankfully we can thereby avoid analysis of the life tally digits. The differences between score digits were more subtle than those between arrows, and a training set was obtained by hand; shown in Figure 3. Five horizontal scan lines were positioned to emphasise differences between the 10 digits. As with the on-screen prompts, the simplistic colour scheme of the score digits eased the matching process; though the white pixels of each digit do host minor variations, requiring a fuzziness in the matching of “white”; otherwise often `0xffcfff9`.



Fig. 3 The 10,000s in the screenshots above provide the digits 0-9 to assist score recognition

2.4 Unique Prompt Identification

The algorithm begins knowing the 156 conventional QTE responses. The DIP switches of SDQ, also supported by Daphne, allow an infinite lives⁴ option. Infinite lives are useful in reducing the time required to search through all moves; an effect which becomes more pronounced as the game progresses. Nevertheless, the outside possibility of multiple correct alternate responses to a single QTE; and with that being the last QTE of a level, means that the algorithm must be capable of starting a new game; following the successful completion of the last one.

Unique identification of each on-screen prompt is complicated by the pseudo-random level order following a death event. Perceptual hashing was ruled out due to the observation that the lifetime of on-screen prompts may bridge a cut in the animation. Ultimately, it was discovered that the screen coordinates of the *first* on-screen prompt of a level, were unique. Knowing the

⁴ Infinite lives merely stops the lives tally (default is 3) falling, and has no further effect on scoring.

number of QTEs in a level, together with knowledge of the score, was sufficient to track and identify every QTE uniquely.

3 Conclusions and Future Work

A perfect score of 776500 for SDQ was obtained by locating all possible valid alternate QTE responses automatically using the computer vision methods outline above; informing a subsequent playthrough by the author; available on YouTube. Future work could ensure the program⁵ can accommodate different pixel colours and display drivers; and also alternative screen resolutions, including full-screen. Such affairs are of course somewhat prosaic; the specific goal of the project has been achieved. A project which introduced the QTE icons of SDQ into Dragon's Lair through the Daphne emulator could potentially improve its gameplay, and build synergy between it and SDQ.

⁵ The C++ source code is available at https://bitbucket.org/pgk/sdq_explorer.

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The background consists of several overlapping rectangles in various shades of blue, creating a layered effect. A large, white, stylized letter 'E' is positioned on the left side of the image, partially overlapping the blue rectangles. The word 'Exhibition' is written in a white, serif font, centered horizontally and partially overlaid by the white 'E' shape.

Exhibition



Skyler and Bliss



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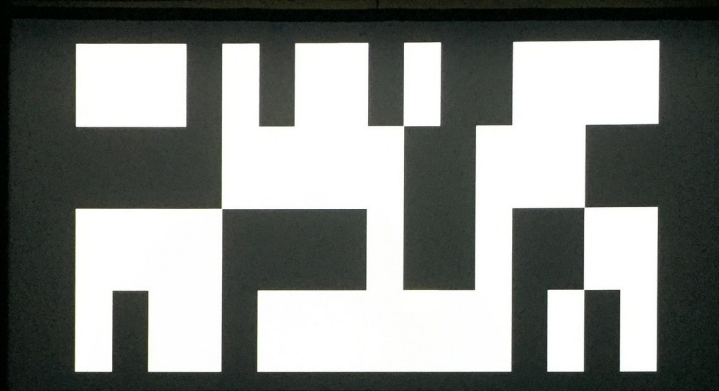
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Keywords: Video Music, Glitch Art, Experimental Electronic Music

Hong Kong remains the backdrop to the science fiction movies of my youth. The city reminds me of my former training in the financial sector. It is a city in which I could have succeeded in finance, but as far as art goes it is a young city, and I am a young artist. A frustration emerges; much like the mould, the artist also had to develop new skills by killing off his former desires and manipulating technology. My new series entitled HONG KONG surface project shows a new direction in my artistic research in which my technique becomes ever simpler, reducing the traces of pixelation until objects appear almost as they were found and photographed. *Skyler and Bliss* presents tectonic plates based on satellite images of the Arctic. Working in a hot and humid Hong Kong where mushrooms grow ferociously, a city artificially refrigerated by climate control, this series provides a conceptual image of a imaginary typographic map for survival. (Laurent Segretier)



Up Down Left Right



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Keywords: Generative Art, Aesthetic Function of Contingency,
Permutation Narrative

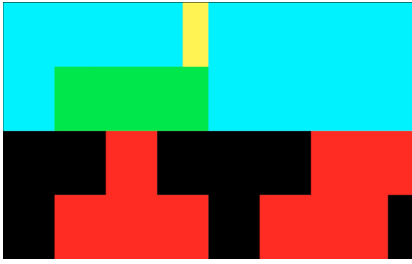


Fig. 1 Up Down Left Right
(https://www.youtube.com/watch?v=Gv_o-Cw4h9M)

Up Down Left Right is an audio/video installation that generates a 'permutation narrative' in realtime based on the concept of contingency. The character in this narrative is a little yellow cursor that creates bass tones as it moves through an unstable world of shifting-dissolving color blocks. The cursor's behavior is solely governed by its internal ruleset in response to this dynamic environment: white = up, black = down, red = left, blue = right, etc... An algorithm randomly selects permutations that control how the color blocks are animated as well as how the sounds are triggered. There are a finite number of color block landscapes that form around the cursor as it moves. The transformation from one landscape to another completely depends on the cursor's coordinates at the time of change: x-coordinate determines time length of the next landscape; y-coordinate determines which landscape to trigger. Thus, the cursor's behavior influences the environment just as the environment influences the cursor's behavior. Different landscapes offer the cursor different navigational potentialities/limitations that alter and shape the musical patterns and overall form of the piece. Since the underlying permutations are randomly chosen, each time the piece runs the cursor's trajectory will not be the same and the narrative will have a different sequence of events.

This piece is generated by a compositional system that I wrote in Max/MSP/Jitter. The system creates permutations of 16 numbers that control the order in which all sonic and visual events occur. The 16 numbers are partitioned evenly into 4 sets, called 'ensembles'. Each ensemble is generally given either a distinct range of frequencies or exemplifies a certain characteristic in some other musical parameter. The permutations are generated using algebraic group theory, specifically the symmetric four-group. The symmetric four-group permutes (1) the order in which the four ensembles occur relative to each other and (2) the four numbers that make up each ensemble (see figures 2-3). These permutations however are rarely made explicit on the surface of the work. An exception is the landscape that has only blue squares whose configurations represent the ensemble patterns in fig. 2. The Jitter (visual) component of the system produces two matrices on the screen: 4 x 16 and 16 x 16. The first matrix manifests in the color block landscapes, the second in the cursor's movements. In the 4 x 16 matrix, the 16 color blocks (often of the same hue) in each of the 4 rows are animated according to the underlying permutations. The cursor is mapped to bass tones in the 16 x 16 matrix that increase in frequency from bottom to top of the screen along the y-axis.

Fig. 2 24 Permutations of 4
Ensembles

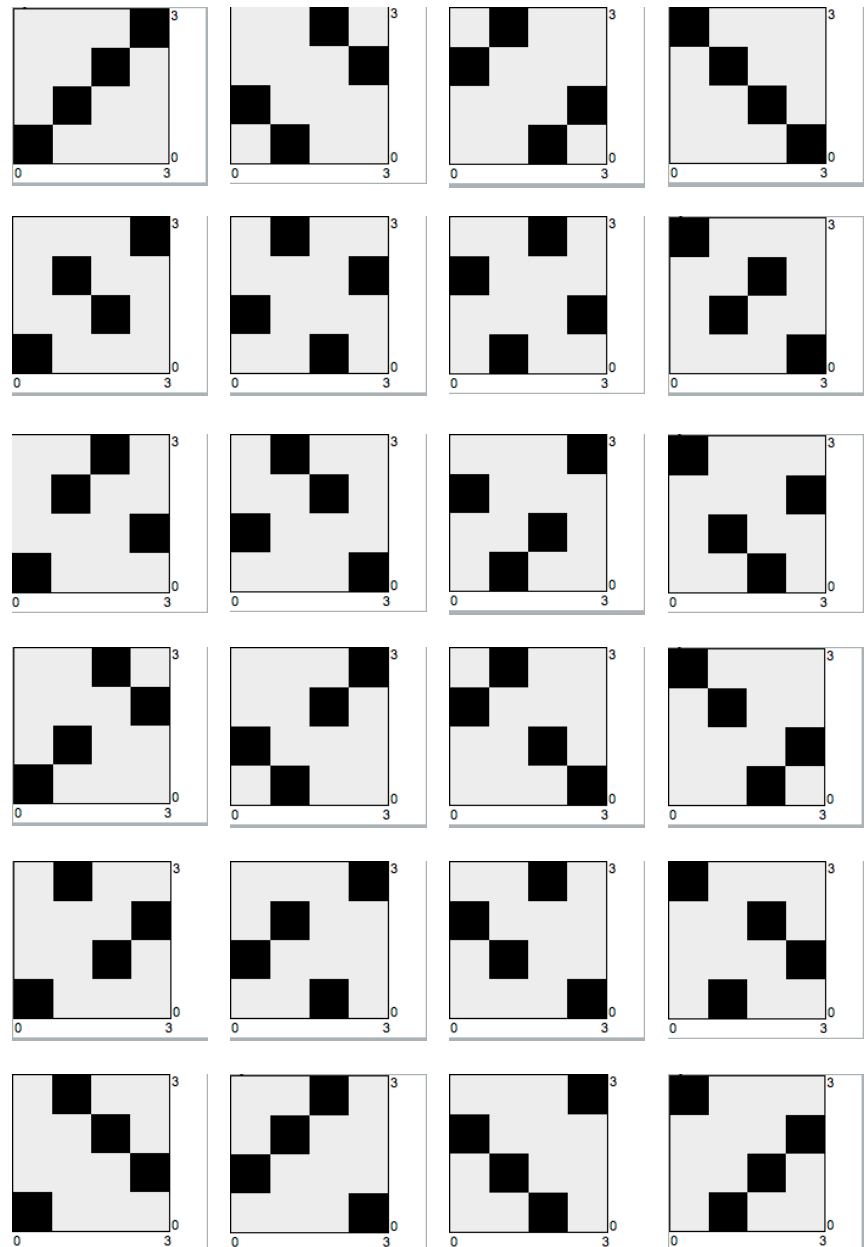
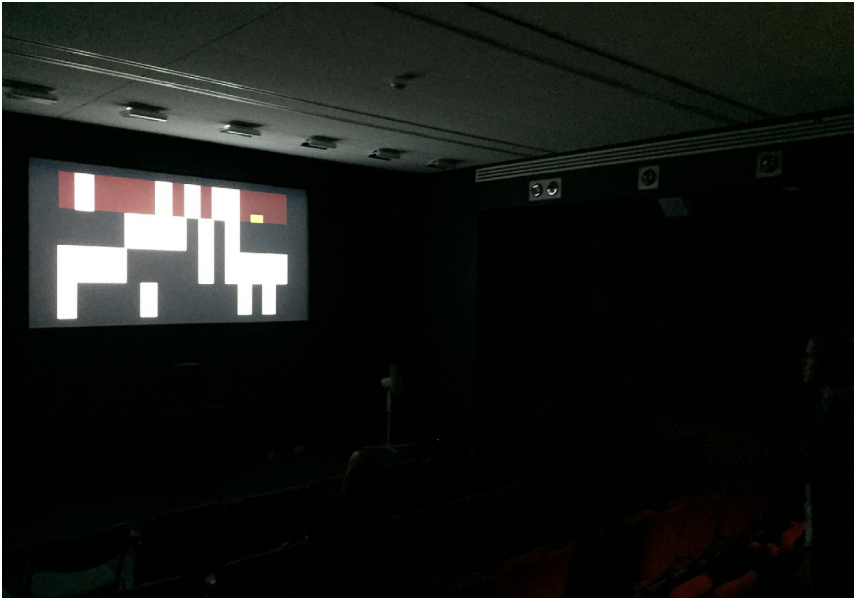
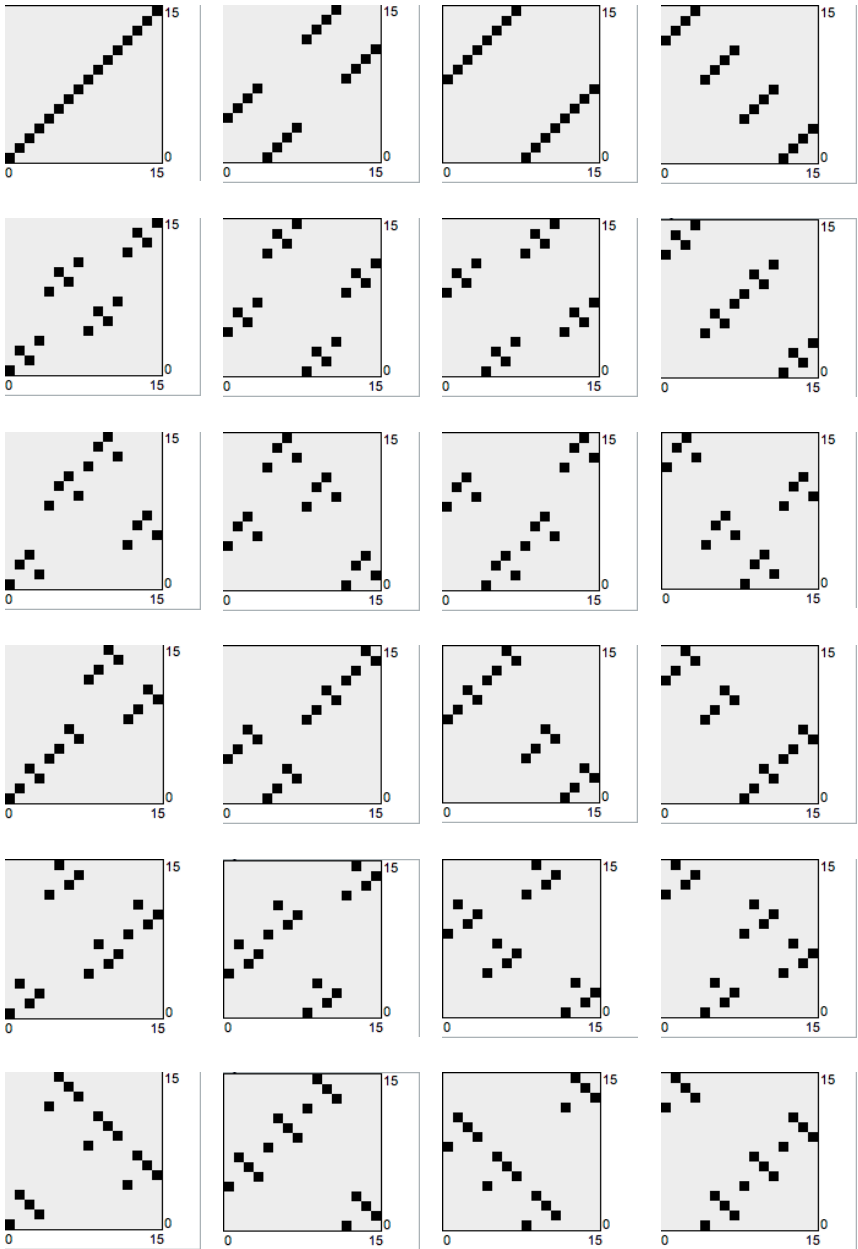
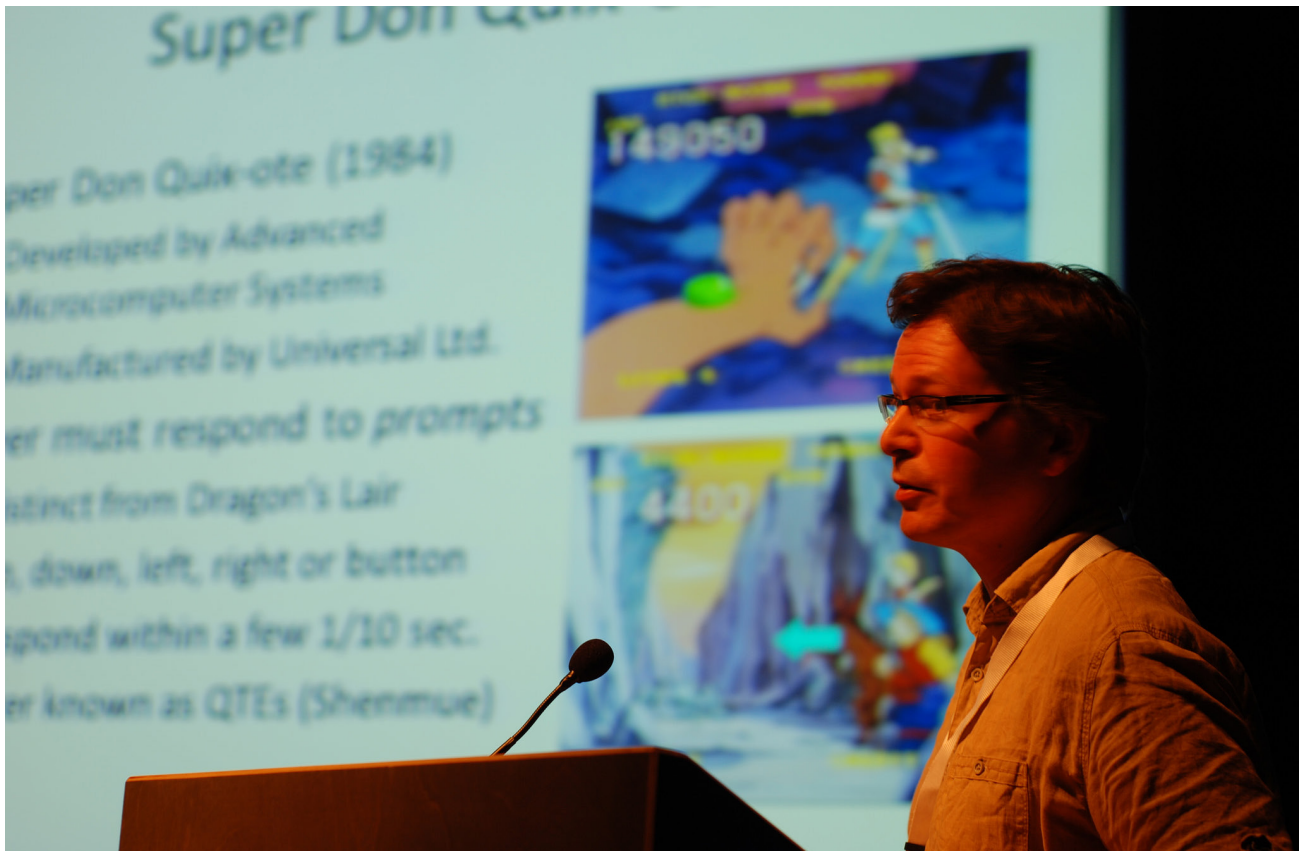


Fig. 3 24 Permutations of the 4 Ensembles, Each Containing 4 Event Generators





The Maximum Score in Super Don Quix-ote



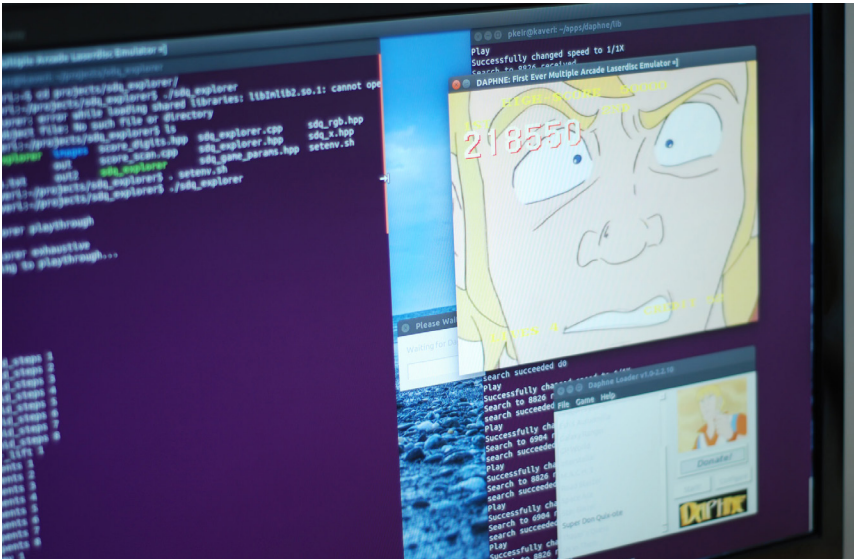
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Keywords: Videogames, Retrogaming, Laserdisc, Artificial
Intelligence, Computer Vision, Easter Eggs





Data Exploration on Elastic Displays using Physical Metaphors



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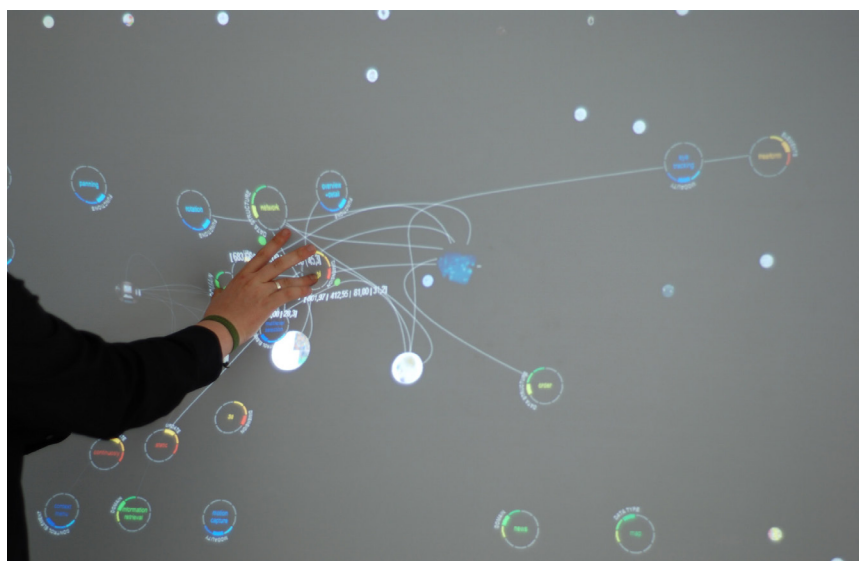
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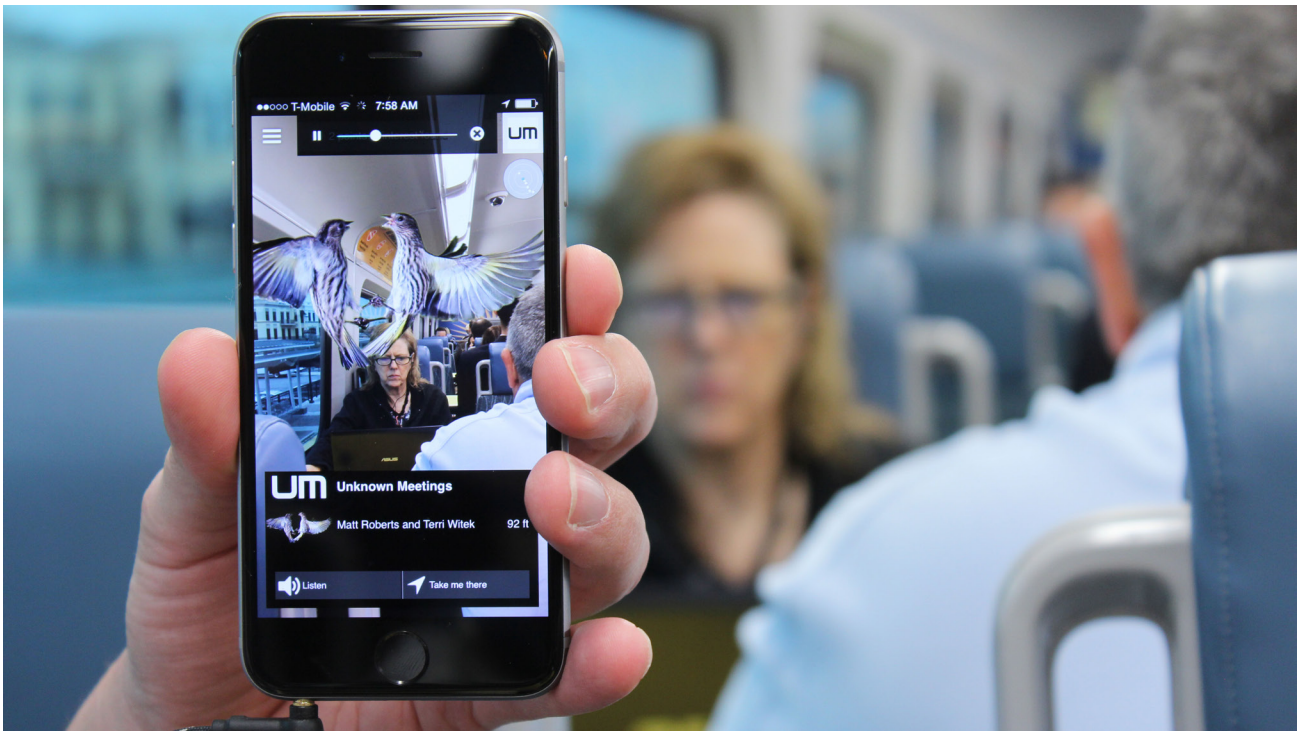
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Keywords: elastic displays, information visualization, haptic
interaction





Unknown Meetings



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Keywords: site-specific, augmented reality, transportation

Unknown Meetings is a site-specific augmented reality project for the Glasgow Subway that takes as its premise the awkward and surreal encounters that occur on daily commutes. Subway riders activate via smart phone both an “unknown” object moving over the actual landscape and an accompanying brief poetic audio file which considers such encounters.

These are activated whenever the train approaches a station. Commuters use the free Augmented Reality app Layar on their smart phones to see a floating image—usually an out-of-place object—and hear a brief accompanying text. Stations are nex-uses of anxiety when we commute—is this our stop? By floating objects and words that offer still more unexpected juxtapositions, Roberts and Witek try to shift the anxiety of arrival onto disruptive ephemeral “connections.”

Unknown Meetings evades the political feuds, environmental upheavals, and social displacement with which ordinary public transportation is so often burdened. It thus offers a critique of systems of connection as it disrupts a sleepy morning or weary late afternoon commute with singularly odd encounters.





Colorigins: Algorithmically Transforming Subtractive Color Theory Pedagogy



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Keywords: *Colorigins*, color theory, color mixing algorithms, gamification, pedagogy, interaction design, interface design, design process, Sifteo Cubes, physical/tangible computing.

Colorigins is a tactile color mixing and matching game designed and developed for the Sifteo Cubes tangible computing platform. By physically manipulating a set of Sifteo Cubes, players attempt to match a target color by mixing a provided set of source colors. Throughout the process of color mixing, players can gain experience with key color theory concepts such as value, saturation, tints, shades, tones, complements, chromatic neutrals, and the relative visual strengths of particular colors. A custom algorithm that references the spectral reflectance values of *Colorigins*' source colors enables the game's digital approximation of subtractive color mixture.

1 Introduction

Colorigins (a video demonstration is available at <https://vimeo.com/97997307>) is the first in a series of speculative art and design learning experiences (designed and developed by the Experimental Interface Lab, the author's practice-led research entity) that leverage emerging and novel digital technologies. Some of these experiences take the form of manipulatives, or learning tools, intended to transform conventional approaches to art and design pedagogy.

Colorigins presents a softly gamified approach to learning elements of subtractive/reflective color theory. The game objective is to match a randomly generated target color by mixing it from a set of source (Johannes Itten's conventional primary and secondary) colors. The target color is generated by using *Colorigins*' color mixing algorithm to create a mixture of multiple source colors; generally, target colors mixed from a greater number of source colors are more difficult to match than target colors mixed from fewer source colors. Throughout the process of color mixing, players can gain experience with concepts such as value, saturation, tints, shades, tones, complements, chromatic neutrals, and the relative visual strengths of particular colors.

2 Platform and Interface

Colorigins is specifically designed and developed for the Sifteo Cubes interactive gaming platform. The Sifteo base stores and runs software built for the platform, connecting wirelessly to up to twelve 1.7-inch square cubes. The cubes each feature a touch sensitive LCD, an accelerometer, and proximity sensors so that the cubes know when and where they are in contact with one another (Merrill et al. 2012). *Colorigins* leverages these features to create an engaging and intuitive color mixing experience, fusing

the distinctively physical experience of mixing color (like paint on a palette) with the advantages of the digital medium (including *Colorigins*' custom color mixing algorithm).

3 Color Mixing Algorithm

The physical variables of subtractive color (such as ink/pigment characteristics, surface quality, and ambient/environmental light) mean that the primary components of any colors to be mixed are insufficient for determining the behavior of the mixture (Matsuhiro and Ohta 2003). The color mixing model used by *Colorigins* holds some of these variables constant to approximate a particular type of color mixing experience.

Instead of using primary component values to calculate a color mixture, *Colorigins* uses spectral reflectance values. As visible light consists of a spectrum of wavelengths, any subtractive color can be represented by a series of data values that indicate the amount of light reflected at any particular wavelength. The source colors for *Colorigins* are based on a Munsell palette (5R 5/12, 5YR 7/12, 7.5Y 8.5/12, 10GY 6/12, 5PB 5/12, and 5P 4/12) for which a data set of spectral reflectance values has been determined experimentally (Centore 2014). The palette selection was made to prevent rapid desaturation (as saturation invariably decreases upon mixture) while maintaining equal color value, as well as to ensure a perceptually familiar hue gradation.

Given the proportions and the spectral reflectance values of two colors in a desired mixture, a new set of mixed spectral reflectance values can be produced by calculating a geometric mean (Burns 2015). Adjustments must then be made for the ambient/environmental light (called the illuminant) and gamma. A set of primary component values, in RGB for on-screen display, can then be determined following these adjustments.

Acknowledgements

Special thanks to Scott Burns, a Professor Emeritus in Industrial and Enterprise Systems Engineering at the University of Illinois at Urbana-Champaign, for his insight into the development of the color mixing algorithm implemented by *Colorigins*.

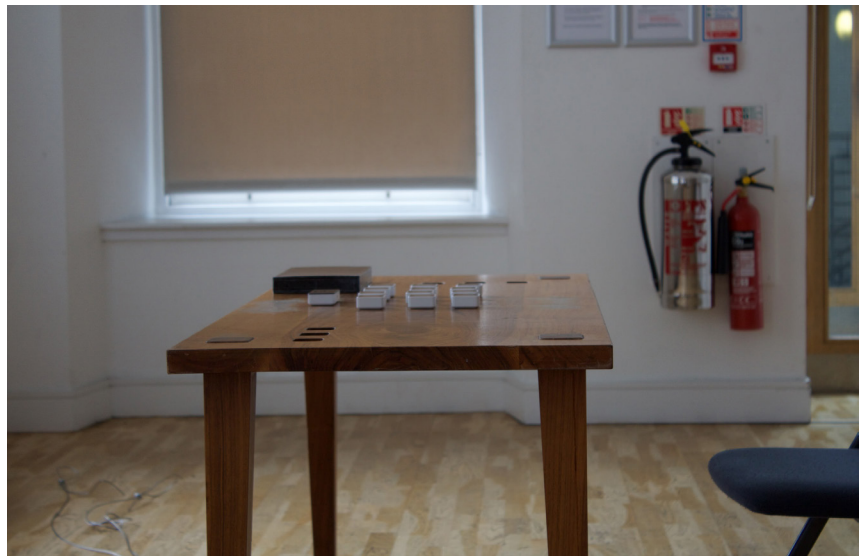
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AR/VR_Putney 1.0. Interactive Media Composition as the Language and Grammar for Extended Realities



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Keywords: Augmented Reality, Virtual Reality, Game-Audio,
VCS3, Putney.

The AR/VR_Putney 1.0 is an interactive installation exploring extensions of our perception of reality. It employs a virtual 1969 VCS3 synthesizer to transcend the boundaries between virtual and augmented realities throughout sound. In the proposed ludic experience, visitors co-interact in a game-like immersive environment, to construct the vocabulary of a shared sonic-centric experience, which triangulates between the real, the virtual and the enhanced. Potentiometers, VU meters, patch-pins and electronic components spring from the AR markers in the walls and wearable t-shirts, so that users can collect, pick them up and transport to the virtual VCS3 in the middle of the room. As the synthesizer parts are being assembled by visitors, the purposely-composed mosaic of vcs3 original recordings becomes gradually organised. As a result, sound and music composition provide the integration for both experiences as extensions of reality.

1 Context

Technologies to augment the human field of view with virtual overlays (ie. AR markers for mobile technology) are rarely explored in combination with 100% computer simulated 3D environments (using Head-mounted VR displays) in compositional environments. In AR/VR Putney 1.0, we are providing an additional angle (the aural) to achieve an integrated experience, where sound is enacted from both the virtual and the augmented experience. It aims to enhance and share the visitors' extensions of reality, while providing an added focus on sound to a technological context, which was born predominantly visual.

2 Technologies employed

2.1 Visual:

Augmented Reality: Unity3D and Qualcomm® Vuforia™ using AR markers.

Stereoscopic Augmented Reality: Unity3D and Qualcomm® Vuforia™ using AR markers visualising on custom Head Mounted Display using Android device and simulation stereoscopic camera with Unity engine and a number of Android devices sending data in real time via OSC (OpenSoundControl) via a Wi-Fi signal.

Virtual reality: We are currently using an OculusRift2, which is connected to a computer running Unity engine which sends /receives data in real time via OSC. Therefore, the user can move around the virtual space, detect objects and calculate its boundaries.

2.2 Audio:

Digital Sound Engine: It consists of VCS3 real sound samples and transformations in MaxMSP controlled by the visitor from Unity via OSC. Example by the author here: <https://vimeo.com/90427321>

Analogue Sound Engine (experimental): An analogue modular synthesizer, which includes a Benjolin module (a Rob Hordijk design) controlled by the visitor from Unity (to Max) and then using Expert Sleepers digital-to-analogue module (es4encoder~Max external). See Fig 4. below.

Quadraphonic system (4x genelec 8030s)

2.3 Technical setup:

Fig. 1 Front view of the installation.

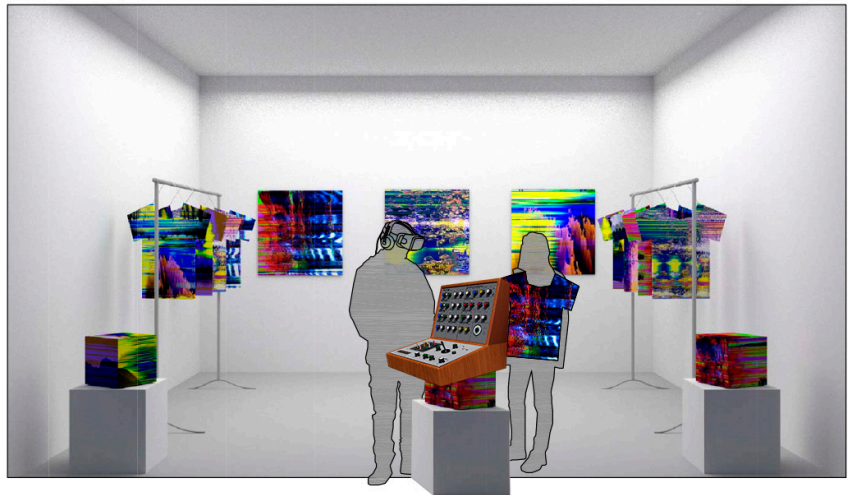


Fig. 2 Space organisation map.

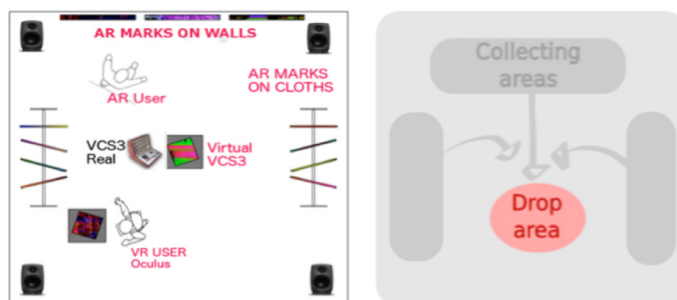


Fig. 3 Virtual components pick-up system.

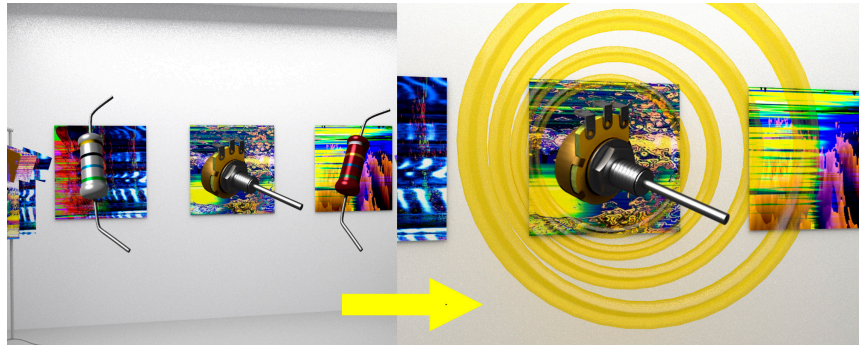
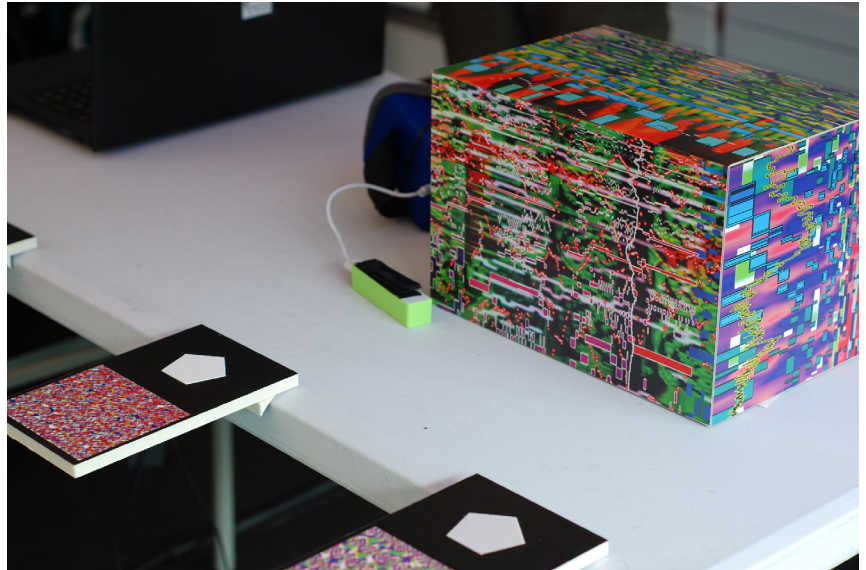


Fig. 4 Virtual analogue VCS3 (left) and Hordijk's Benjolin controlled via an Expert Sleepers digital-to-analogue module.











'Let's Talk Business': an Installation to Explore Scam Narratives



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Keywords: phone scams, audio installation, interactive
storytelling, reverse engineering, activism.

16th century 'face to face' persuasion scams adapted to letters, telephone, fax and Internet with the development of new communication technologies. In many of today's fraud schemes phone numbers play an important role. Various free-to-use on-line tools enable the scammers to hide their identities with fake names, bogus business websites, and VoIP services. With the typology of a sample probe of 374 emails, commonly used in business proposal scams, the emails were categorized and tested to see how believable the proposals sound once the scammers were contacted by phone. The research can be explored in a 5-channel interactive audio installation called 'Let's talk business'.

Introduction

Phone fraud can be described as a 'fraudulent action carried out over the telephone' and can be divided into 'fraud against users by phone companies' (cramming, slamming), 'fraud against users by third parties' (809-scams, dialer programs, telemarketing fraud, caller ID spoofing) 'fraud against phone companies by users' (phreaking, dial tapping, cloning) and 'fraud against users by users' (vishing, SMS spamming). The different fraudulent actions can also be divided into technical hacking, social hacking, and mixes of both. (Rustad, 2001)

Curious anti-scam activists called 'scambaiters' adapted more of the social engineering tactics to find methods to safely communicate with scammers, finding out how the scams work in order to warn potential victims. This artwork focuses on the 'user to user fraud' that is done by email and phone scams. Typically these scams involve storytelling and some sort of social engineering, where the fraudster creates a hyper-realistic 'too good to be true' situation for a mark, in order to extract sensitive data and/ or money from the victim. (Maggi, 2010) (Mitnick, 2002) These scambaiters host informative websites where scams are reported, and forums where people can discuss suspicious business proposals.

Fake businesses and personas can appear more legitimate when connected to a phone number, enabling faster and more personal contact to the victims. (Costin, 2013) By using services like Gmail the scammers gain access to popular VoIP services like Google talk or Skype. In addition to this, call diversion services offer scammers a way to hand out a regional phone numbers, yet still answer to the calls wherever they are. These free tools allow the scammers to hide their real identities and to be in contact with the victims using fake names accompanied with diverted contact numbers. Our intention was to uncover which business proposals

and scam schemes are commonly used and how believable the proposals sound once we called the scammers.

The Dataset

As a raw dataset we took a sample probe of 374 emails with phone numbers, which were collected over a time period of three weeks from Nov. 11 to 30, 2014, from the 'scammed.by' scam email database. In 2010 this website was created under the name 'baiter_base', a place for scambaiting activists who document the activities of Internet scammers. The website provides a service to send in suspected scam emails, which are then automatically analyzed, categorized and published. From the emails we then extracted the phone numbers per country. The top five countries, in total 277 emails, were further categorized according to their narratives structures. Using a VoIP service, we then called scammers from some of the top five countries, trying to cover a variation of the ten scam scheme types. Through this experiment we experienced that the phone conversations were very personal, in comparison to the emails: some scammers were very open to explain their shady businesses, others preferred to use email and keep the phone conversation as brief as possible. Some of the scammers used voice-morphing software to anonymize their natural voices resulting in a rather creepy effect. The conversations with the scammers were recorded and some of the stories were edited and can now be listened to through the SPAM-cans in the art installation.

The Installation 'Lets talk business'

The installation consists of five modified SPAM-cans that are normally used to store precooked 'SPiced hAM' produced by the Hormel Foods Corporation. According to Merriam-Websters dictionary, the naming of unwanted mass advertisement as 'SPAM' originates from 'the British television series Monty Python's Flying Circus in which chanting of the word Spam overrides the other dialogue'. The sketch premiered in 1970, but it took until the 1990s for mass emails, junk phone calls or text messages sent out by telemarketers to be called 'SPAM'. (Templeton) While most of the scam emails tend to end up in the SPAM folder, we chose to mediate these stories through physical SPAM-cans. Transducers and audio players are attached to four of the cans, so that visitors can listen to the scammers' different narratives that were recorded. The fifth device has two buttons: one button connects the visitor to a randomly chosen number from a scammers database, the other button disconnects the call. While most of the scam emails

tend to end up in the SPAM folder we chose to mediate these stories through physical SPAM cans.

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Growing Objects: Testing with Biological Generative Systems



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Keywords: biological design, generative, growth, customization,
emotion.

We intend to present the results of a test that is part of an ongoing investigation where artifacts are produced by biological systems with generative potential. In these systems where nature's randomness and physiological processes have an important role in the definition of form, we understand that artifacts have the capacity to foster new, emotional, connections that arise from their nurturing and from an understanding of their morphogenesis. In contrast to mass-production and co-design systems, for these biological systems to grow into final products, they have to be understood and nourished by their users. Their end results are singular and unique, with aesthetic qualities that arise from the understanding of the artifacts' growth constraints and the bonds that are created with them. The traditional quality canons of mass produced goods are challenged, as the resulting artifacts will not get final shapes that are both polished and free of imperfections, but that are inconstant, gnarly and sinuous.

The test consists on a small series of DIY casts and step-by-step instructions distributed to a group of people to build their own matrices and grow their own products with the intention to better understand how individuals respond to these objects. The casts consist on a STL (Stereo lithography) 3D printable format and a PDF drawing of the cutting dimensions for a plastic sheet. After being printed and cut, these materials are easily assembled and filled with mycelia-inoculated straw. To ease the users' job, they will be recommended to transfer the content of a commercial mushroom kit into the predefined form. Dimensions are constrained by the printing volume of an average low-cost 3D printer, and the initial user group will be selected from people with some experience with commercial mushroom growing kits, ensuring some familiarity with the nurturing process and giving us an emotional comparison between a traditional commercial kit with the only focus on producing edible mushrooms and the possibility of giving the substrate a second use.

Each user will be asked to nurture their artifact into a final object. For this, they will have to follow the normal instructions of the familiar commercial kit, and all options will be of their responsibility: sunlight exposure, room temperature, when and how much to water, growth interruption, etc.. Each user will be asked to make a written log of their options and a photographic register of the mycelia's expansion and mushroom growth and to describe their feelings towards it.

The system and the initial template were designed in order to leave most of the growth constraints choices for the user. We believe that a greater awareness that their actions helped define the final object, will also generate a greater tie-in between user

and object, a connection by emotion and understanding more than the mere relationship of possession.

All outcomes and examples of systems in various growth stages will be presented, we also intend to make available to the general public the templates along with instructions for their replication, allowing the testing to continue into a larger data gathering. Attached is a document with the description of a previous test with a similar technique.



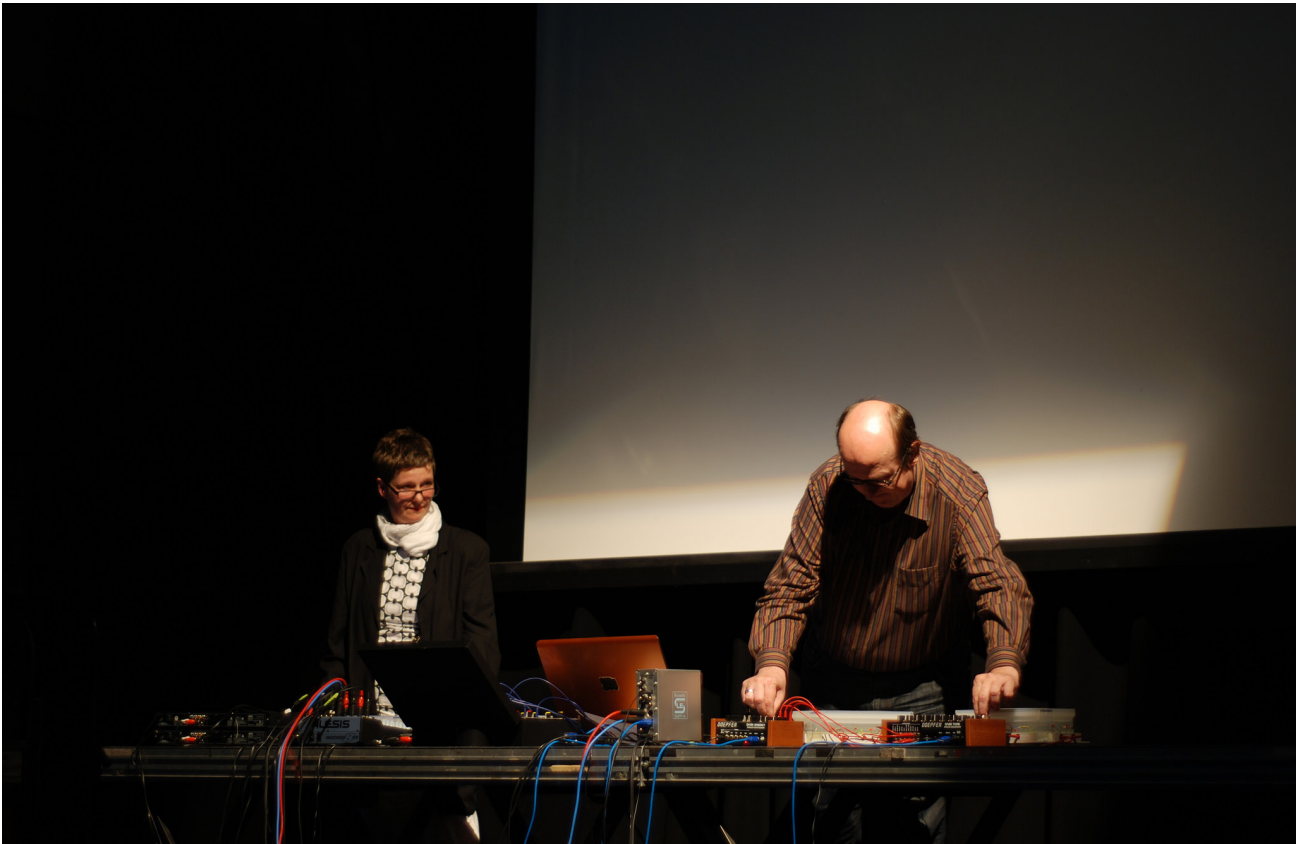




Performances



Fluid Control: Media Evolution in Water



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Keywords: controller, computer interface, water, electronic music, video, mass inertia, fluid, potentiometer, switch, fader





The Scottish School of Flower Arranging: Rikka



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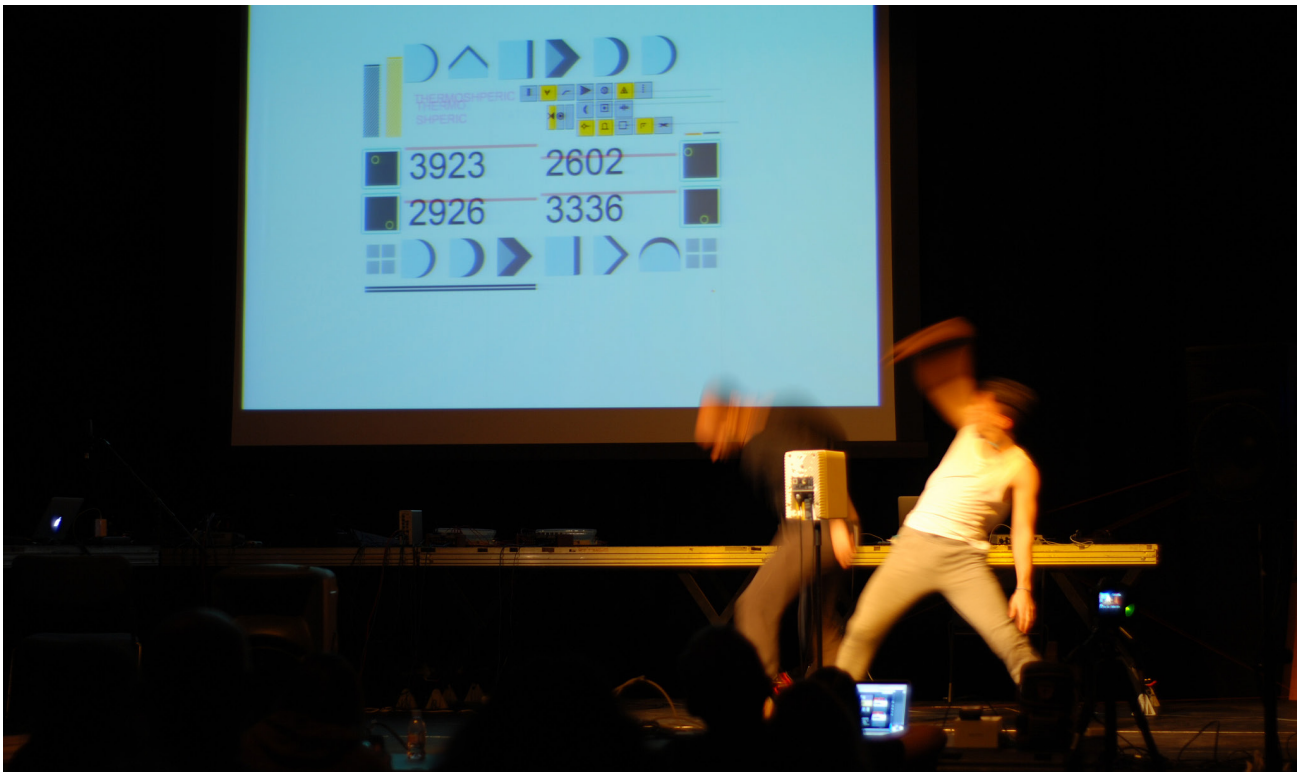
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Keywords: Live-electronics, improvisation, instrument design

The music of the *Scottish School of Flower Arranging* seeks to explore, by means of hand-made acoustic and digital tools, found objects and materials, an intimate sound world created from a few simple and basic elements which change slowly over time and which investigate asymmetry, materiality, irregularity, economy of means, and the emulation of natural processes. The name is derived from the Japanese zen-influenced practice of flower arranging and pays homage to similar socio-aesthetic activities such as the tea ceremony, where the qualities of restraint, careful placement of elements and detachment are highly valued, as are attributes of wabi-sabi such as the imperfect, the impermanent and the intimate.



Thermospheric Station: Seeking out the Aesthetics of Interactive Post-Digital¹ Artwork with the use of Gametrak



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Keywords: dance and sound collaboration, interactive, sound art

Fig. 1 *Thermospheric Station* – Live performance at Flux Factory, New York, in 2014. A dancer is tied onto a column with the red wires of Gametrak to represent the power of gravity. The centre of gravity is the column not the ground in this performance. (Choreography by Dane Lukic and Quentin Burley / Photograph by Amela Paricic)



1 The term ‘post-digital’ in the title has the same meaning as how Kim Cascone used in his essay *The aesthetics of failure: ‘post-digital’ tendencies in contemporary computer music* (2000).

2 The Gametrak controller was invented in 2000 by Elliott Myers who founded In2Games and designed for home video game platforms. A standard potentiometer turns as the wire attached to the base console is pulled in and out and the analogue information of distance and location transforms to digital data.

3 Kinect is a motion tracking device by Microsoft for Xbox games and it was introduced in 2010 for the first time. It provides full-body 3D motion capture, facial and voice recognition capabilities.

4 The sound composition is also programmed to stop if performers do not go back to the beginning position. To continuously interact with sound the performers are forced to be back to the beginning position regularly.

5 A pair of wearable gloves which can be attached to the end of wires are included in the Gametrak games package. More information can be found here: <http://uk.ign.com/articles/2004/09/16/introducing-the-gametrak>.

Last accessed 24 April 2015

Thermospheric Station is an interactive dance and sound collaboration using the game controller, Gametrak², as the interface to connect sound and movement. Gametrak’s motion tracking system is very simple compared to other interactive technology now days such as Kinect³. In this article I explain how Gametrak was used in *Thermospheric Station* to create sound and dance improvisation with its very reduced and limited functions. Most importantly, I illuminate the aesthetics of the composition as a digital artwork with the use of motion tracking technology of the controller.

In *Thermospheric Station* the dancers are expected to create choreography motivated by the properties of Gametrak and not to use the device only as a sound controller. Brian Massumi insists, “The strength of interactive art is to take the *situation* as its ‘object’ but “not a function.” (Massumi, 2011:52) According to the theme ‘Gravity and non-gravity’ the choreographers interpreted the situation as if they were in a space where gravity and non-gravity co-exist. One of them was tied onto a column with the red wires of Gametrak to represent the force of gravity, but the other performer was allowed to move freely as a contrast (Figure 1). The red wires attached to the dancer’s body force the dancer to go back to the beginning position as if the gravity limits the dancer’s movement⁴. At the very beginning of the performance sound is almost synchronised with the fragmented movements of the dancer who is connected to the column. As the other dancer steps into the set the fragments of noise changes to sustained high-pitched note demonstrating the tension between the two dancers. I focused on composing ‘gestures’ of stretching and pulling sound, and then progressed the sound to express the overall tangled ‘situation’ with the wires (Figure 2). Towards the end of the performance the synchronisation of sound and movement becomes very loose.

This is to let performers to have a moment to express movements “emerging ‘with’ technology, rather than technology itself” (Stern, 2013:64) to look for an extended meaning of the device as a part of the composition.

Fig. 2 *Thermospheric Station* – Live performance at Flux Factory, New York, in 2014. A dancer is entangled with the red wires of Gametrak and the wires create complex tangled lines. (Choreography by Dane Lukic and Quentin Burley / Photograph by Amela Paric)



Gametrak controllers were packaged mostly with golf or fighting games because they were supposed to track physical movement of a player's hands connected to the base station with two red wires⁵. It was released as a sensational controller which could track moving points of the wires in 3D space with its stability⁶, although it did not survive for long in the game market after Kinect was released. However, the ‘failure’ of Gametrak in the market inspired me, and I have sought out what made my collaboration special using the aesthetics of this particular technology. Gametrak only can track distance and location of an object connected to its red wires, and perhaps this reduced capability was the main reason of the failure. Although it has very limited technology to track motions, it has a distinguishing appearance from the other motion tracking devices; The red wires of Gametrak expose tracking points of an object highlighting how the object is connected to the centre of the device in 3D space and how it moves from one point to another. This visible analogue information of the wires' distance and location transforms to digital data. I could find a similar aesthetics from Ryoichi Kurokawa's visual work in *Rheo: 5 horizons* which shows photographs of real landscapes and then reveals their symmetrical lines in digital domain behind on five HD displays⁷. Similarly, the Gametrak's red wires expose the “background” of interactive “digital technology to the foreground.” (Cascone, 2002) with the tangible and visible method. In this performance my focus of interactivity as a composer has moved from how to track a performer's physical

⁶ <http://uk.ign.com/articles/2006/04/14/exclusive-gametrak-interview-with-developer-in2games>. Last accessed 24 April 2015.

⁷ <http://www.ryoichikurokawa.com/project/5horizons.html>. Last accessed 24 April 2015.

movements through technology to the aesthetics of gestures and shapes created by the extendable wires of Gametrak.

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Keywords: Improvisation, Live Coding, Microtonal Composition, Spatial Music





Putney for game-audio



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Keywords: composition, game-audio, vcs3, analogue modular
synthesis, procedural audio, interactive media

Putney “K” is an interactive media work featuring a virtual VCS3 synthesizer created with a graphics-physics-game engine and originally composed and designed by Ricardo Climent. In 2015 the piece’s concept was further explored in the form of two collaborations, which expanded its existing degree of expression and interactivity. The first incorporated Mark Pilkington’s creative input via the live performance of an original EMS VCS3 analogue synthesizer (interacting with the virtual one played by Climent), and the second was a sound installation entitled ARVR Putney by Alena Mesarsova (Manusamo&Bzika), which combined augmented and virtual reality. This concert version introduces a range of uncontrolled sonic fantasies (aural paidia, as in R. Caillois’s typology). The main character (called Putney) is a potentiometer and sonic scanner retired from a classic 1969 VCS3 synthesizer. To return home at Putney Bridge in London, the performer must collect components (vernier pots, VU meters, knobs, pins), electronics (PICS, capacitors, resistors) and circuit schematics and needs to solve a number of aural challenges (ludus) and earn enough compositional esteem. The game engine’s play-through provides a dynamic graphic score for Pilkington, while opening communication channels to allow a number of performers to take part in an extended musical network. The performer of the real VCS3 takes on the role of a game player and interjects dramaturgy through the expression and manipulation of the instrument, to form a dynamic musical interplay. The synthesizer’s unique semi-modular design and wild/chaotic character portrays a disruptive link

Fig. 1 Putney (the Potentiometer) as seen in Unreal Engine 4.



within the flow of the piece, while its tactile embodiment extends the virtual beyond the frame of the screen. The act of play and containment becomes the boundaries that provoke intertwined emotional responses informed by chance, indeterminacy and algorithmic decision-making processes. Two systems of difference between the poles of the virtual and the real provide a homomorphic experience in which the viewer becomes engaged and immersed. The point of intersection of the two sensory fields is a thrilling and inspiring experience as it coexists between congruence and incongruence. The giant vcs3-gamepad controller for Putney was commissioned to and designed by Iain McCurdy.

Fig. 2 Mark Pilkington with VCS3 and McCurdy's giant joystick.



Fig. 3 Putney in the VUMeter room as seen in Blender Game Engine.

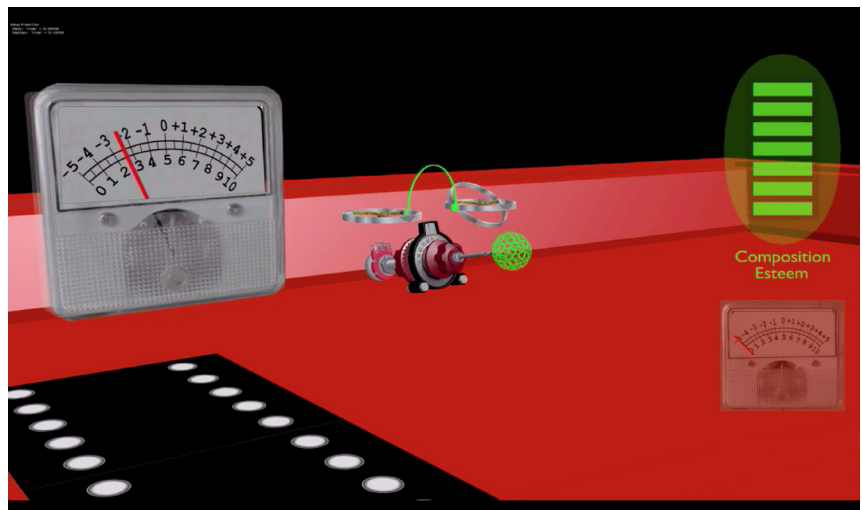


Fig. 4 Level Blueprint section in Unreal Engine 4.

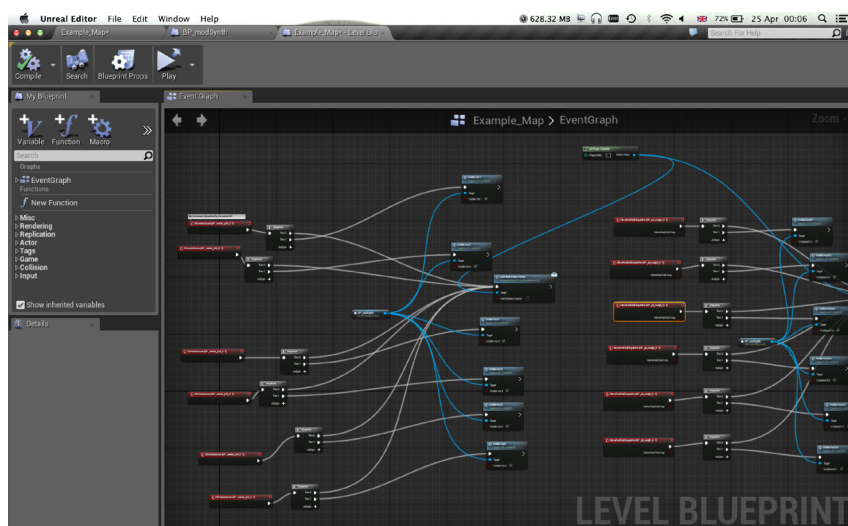
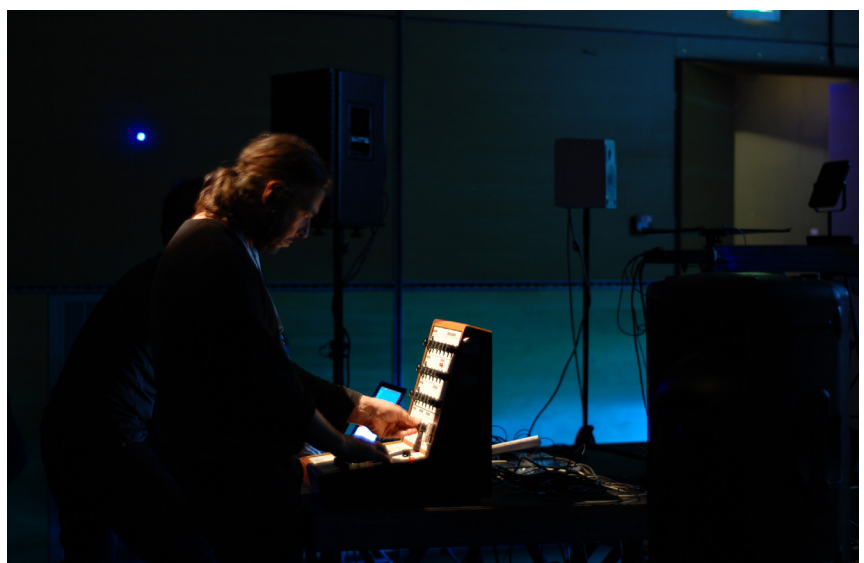
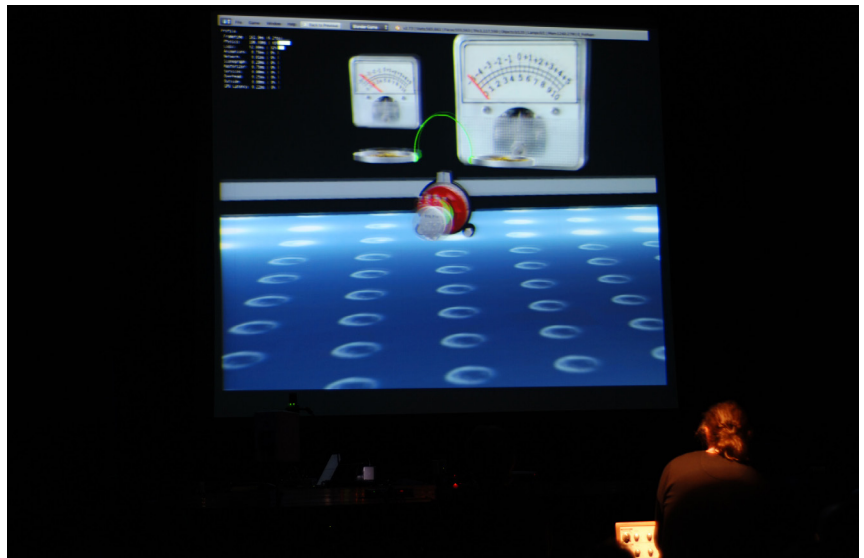


Fig. 5 EMS studio recreated with Synthi 100 in the background.



Fig. 6 Visit in the summer of 2014 to Putney Road 277 (original home of the EMS studios in 1969, currently a hairdressing shop).







Drei Mal Acht || 24



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Keywords: Digital Signal Processing, Generative Art,
Conceptual Writing, Music

Drei Mal Acht || 24 is a performance for a personal computer, a human being, a “construction kit” of various text fragments, for a “steering force” motivated particle system and the audience.

Starting with simple text fragments about very basic bodily functions which are usually taking place without any reflection or conscious control, like blinking or breathing, the work combines different layers of text, human interaction, computational process and perception.

Various algorithms (used to define how particles interrelate to each other) are waiting in line to successively hijack the parameters of granular synthesis in a Csound data set created for live interaction. The particles roam, along apparently random coordinates, continuously trying to find the best way in an ongoing calculation process. In combination with concentric circles the particles move towards each other simulating an emergent system and implying further fields of association.

1 Introduction

To use language for whatever purpose always means to use the transformational apparatus of the language to refer to something that already exists – ideas, attitudes and discourses. Language structures perception and it is needed to connect with others, for collective decisions and to establish a relationship between the individual perception and the external world.

The linguistic codes, culture-specific communication and collective understanding are both a blessing and a curse. The perceptual filters of the mind are defining the frame of the thinkable - instead of having an immediate experience, we are putting everything in its well known place.

Human perception works very well without knowing anything about the complexity of biological and chemical processes which are precondition and cause for any perception at all. You don't need the ability to explain what your eye is or does to see a tree when it's right in front of you.

The linguistical examination of breathing is not the same as the act itself, it is nothing but a reference chain comprehensible to any person familiar with the rules implied.

2 The Performance

The system starts with immediately mediated banalities. Very basic bodily functions that are usually taking place without any reflection or conscious control, like blinking or breathing, are being verbalized and transformed into soundscapes via granular

synthesis. The sound of the phrases itself is dismantled into spare parts, divided into pieces and transformed.

The artificial nature of the linguistic signs, the inner distance between the object and what is happening (between the signifier and the signified) is addressed to different levels of analyzing and performing by the syntax of the sound and the sound of the syntax.

In the course of this process the linguistic modules are gradually expanded – the expressions are moving away from the obvious, creating a field of associations, leading to abstractions, producing ambiguities and focusing on its own deficiencies.

In analogy the audio synthesis is increasingly driven by the data of the particle system generated by Processing.

The balance of power between human interactor and „steering system“ is shifting into the direction of the particles. As the flow of language grows more complex, allowing reflection on one hand, making action more difficult on the other, the scope of action is cut down for the sound artist. The performer is continuously losing control of each parameter that „steers“ the granular synthesis to the particles of the generative system.

2.1 Data Flow

The data of the Processing Sketch is transferred to the Csound instrument to manage the parameters of granular synthesis. Here it forms an aleatoric element gaining more and more control over the process. The original sound (in this case, a language sample) is dissolved and recombined; fractals unfold from micro-, meso- to macro-level.





Algorave



Rectangular Rotation



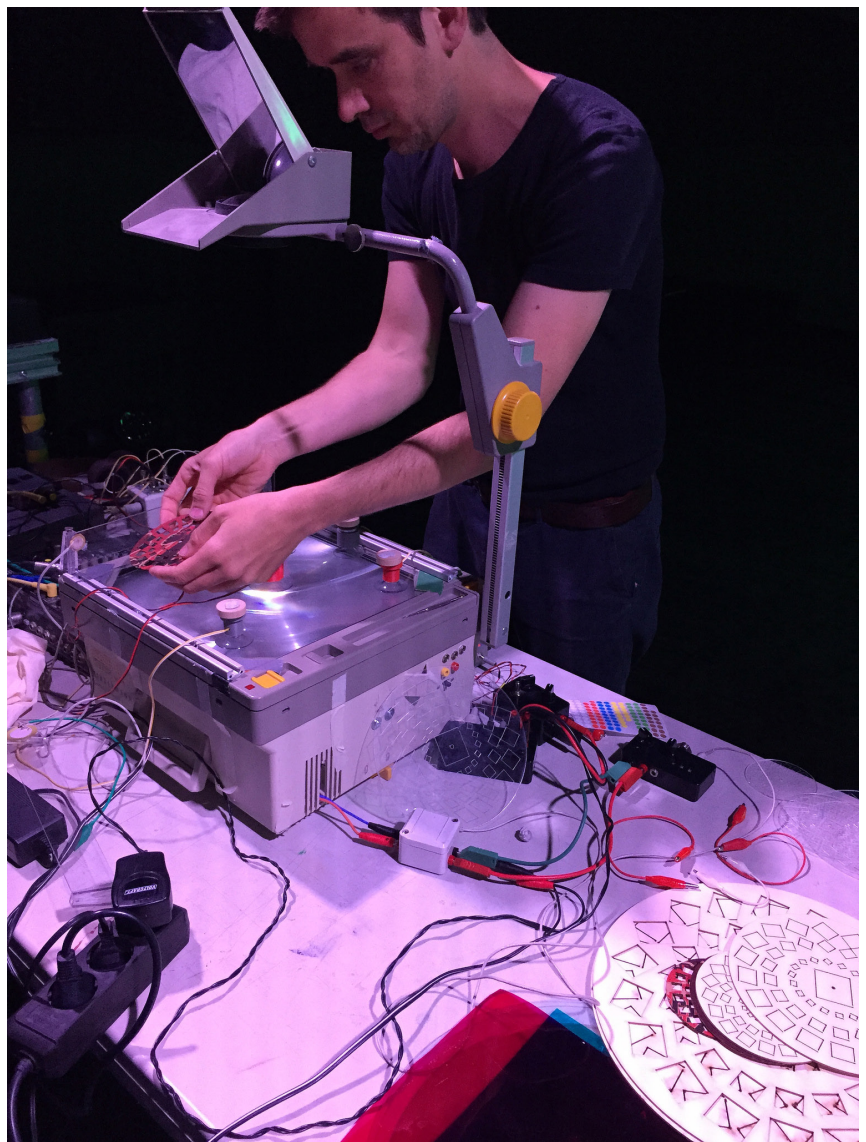
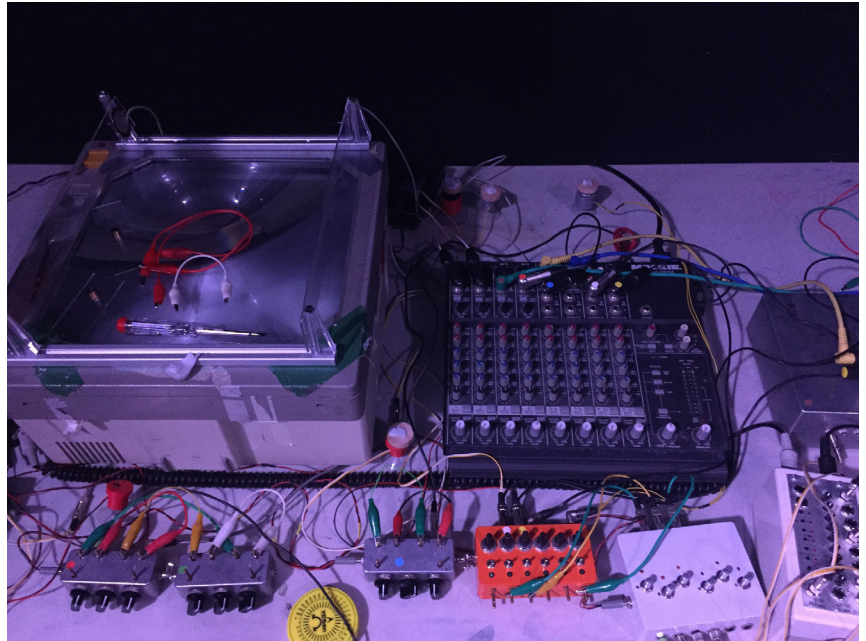
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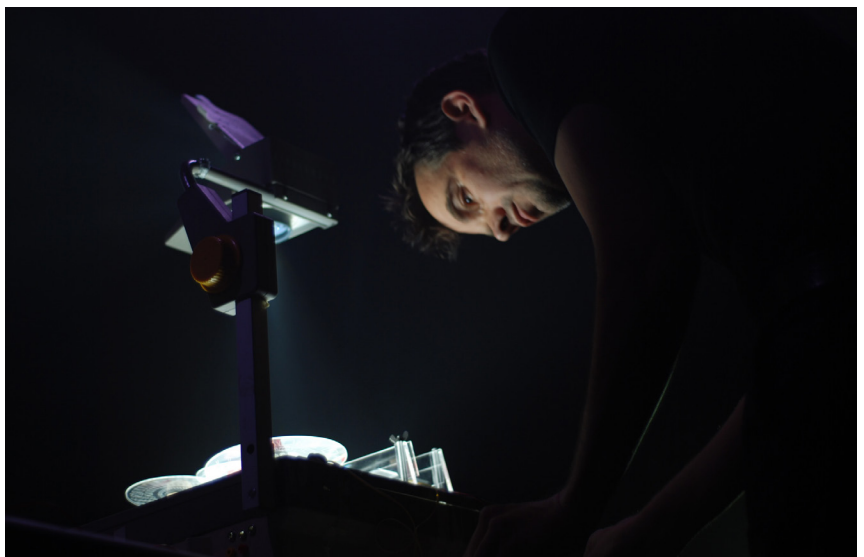
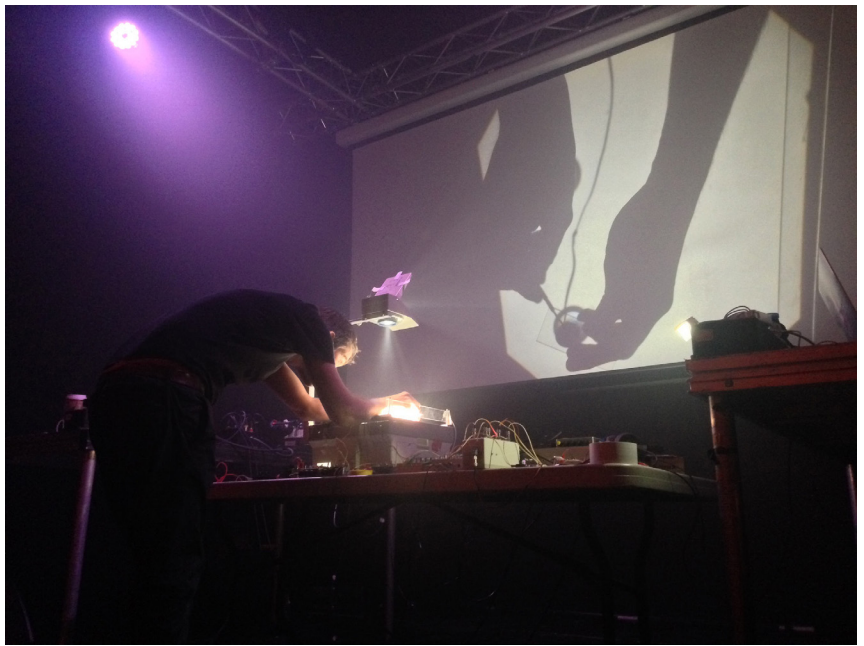
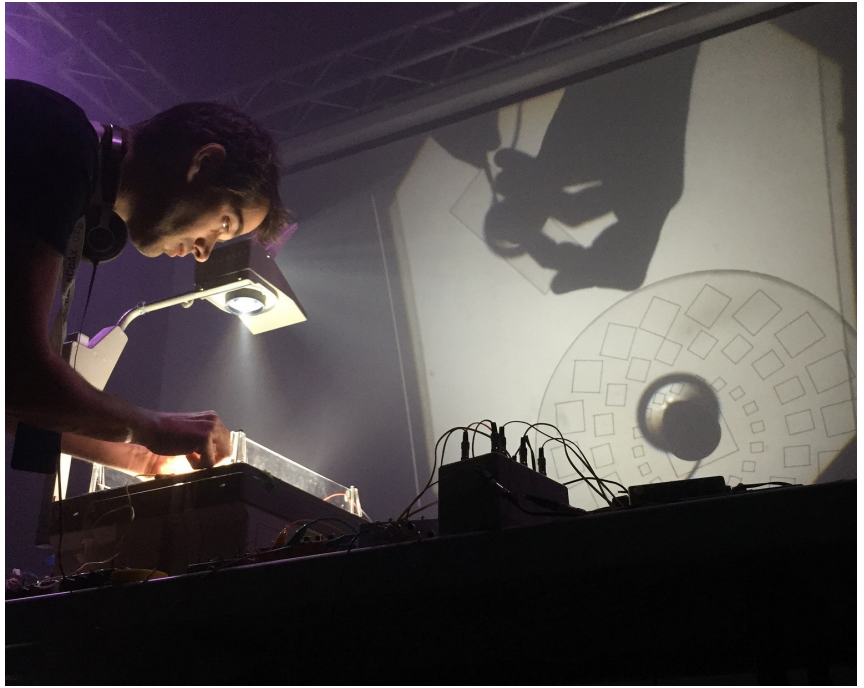
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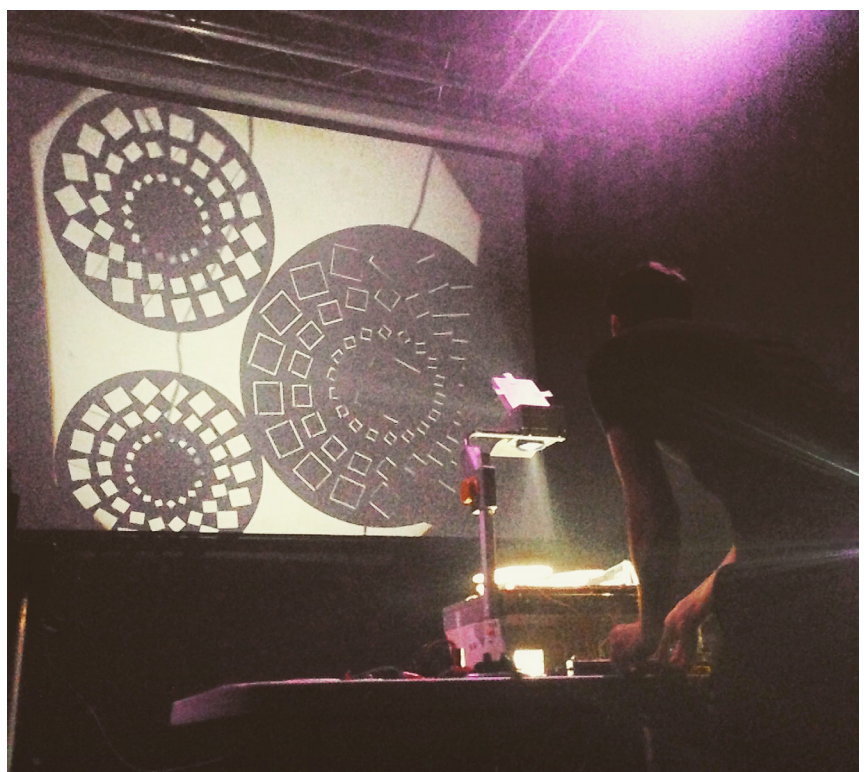
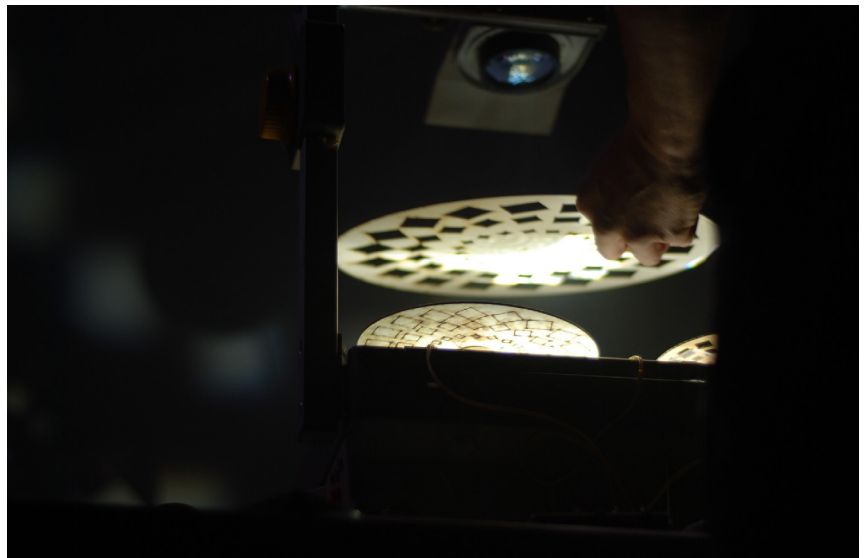
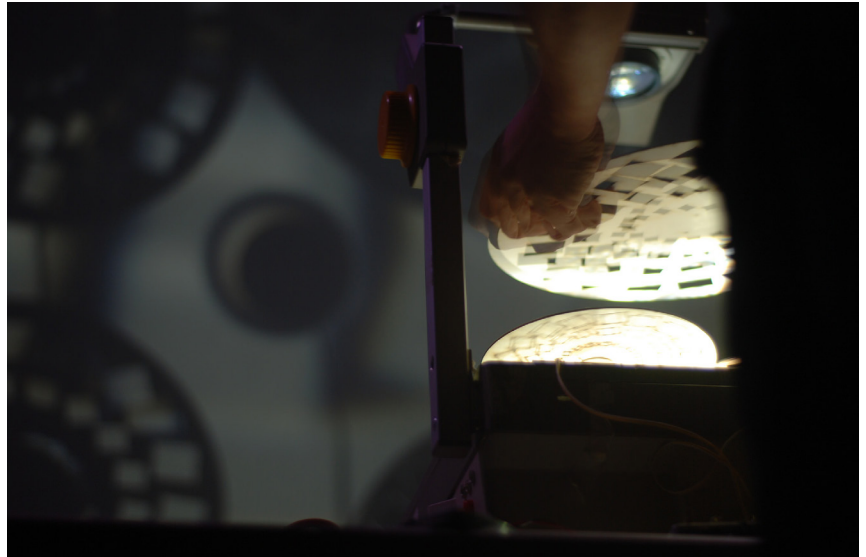
Christian Faubel

Academy of Media Arts Cologne
c.faubel@khm.de

Rectangular Rotation is an audiovisual performance based on a modified overhead projector, the *ZoOHPraxiscope*. Analog electronics are used to control motors and generate movement and sound. These movements are projected and create an animated shadow play that is always in sync with the sound. In addition the projector light can be switch at hight rates, to create flickering light and cinematographic animation of rotating picture discs.









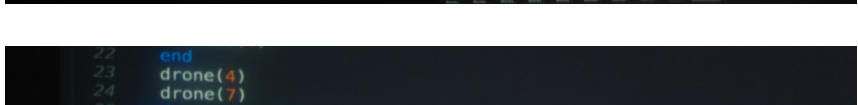
Algorave Performance



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Martin Zeilinger
Ontario College of Art & Design
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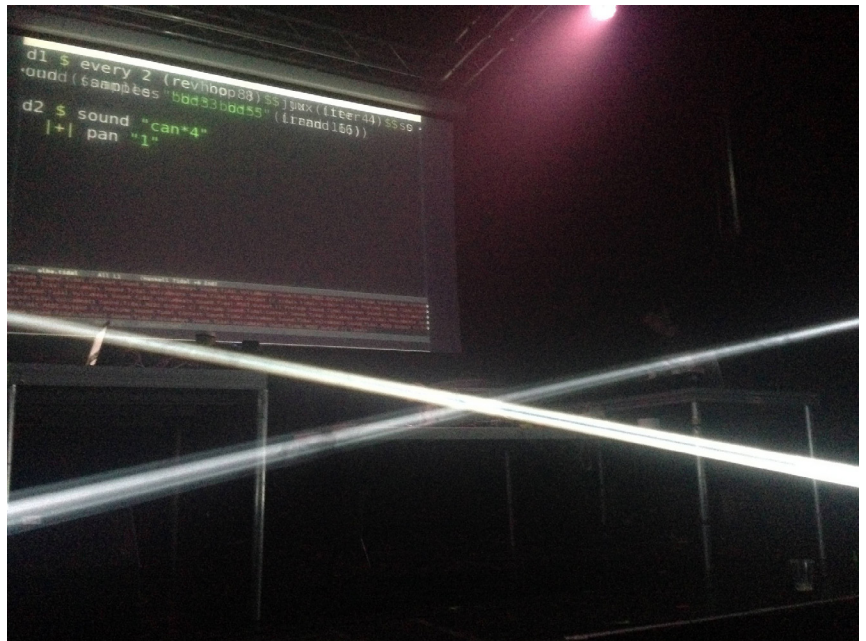
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Alex McLean
ICSRiM, School of Music, University of Leeds
a.mclean@leeds.ac.uk





Algorave Performance



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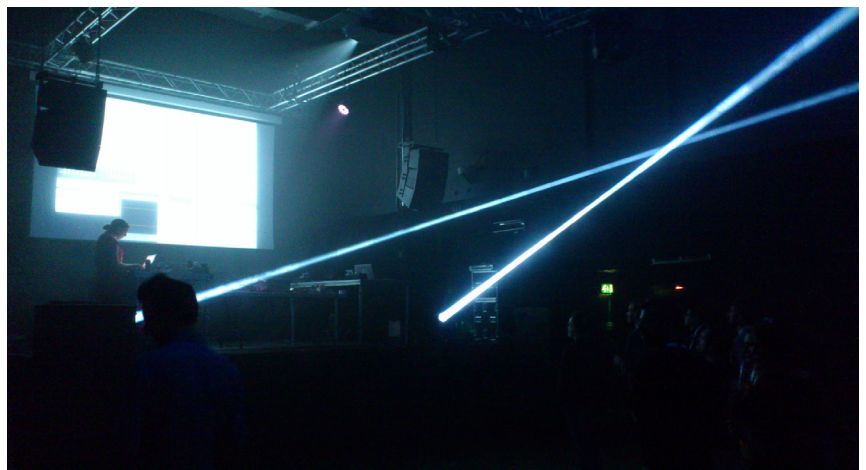
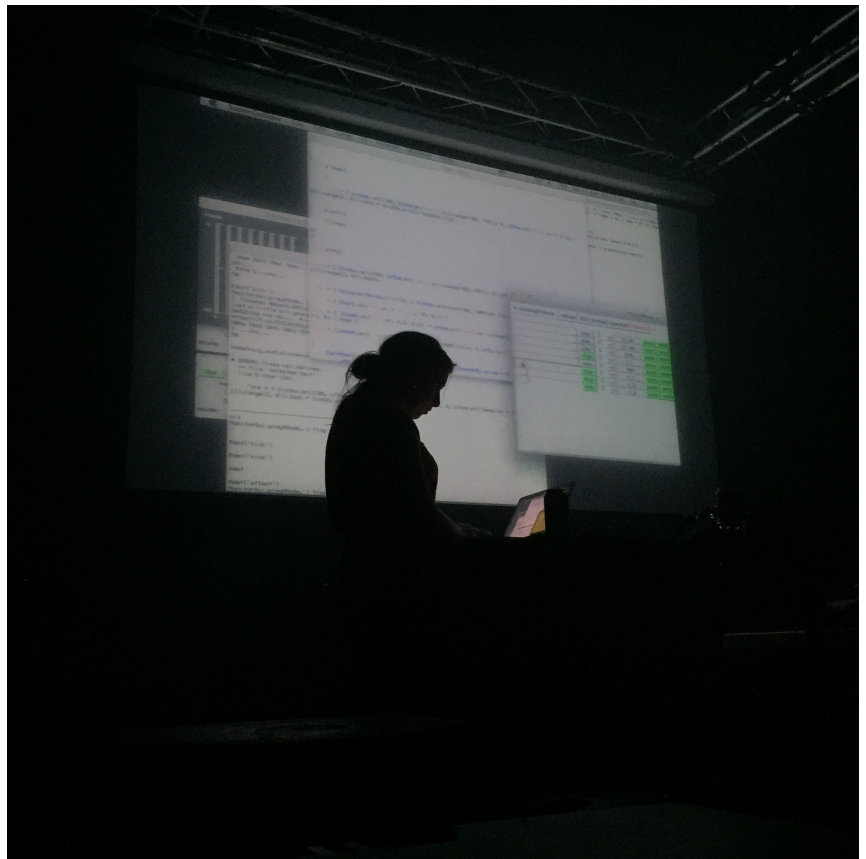
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Shelly Knotts

Durham University
michelle.knotts@durham.ac.uk

As code-fuelled ravers dance to wonky algorithmic glitches, an onstage battle of wills will occur as the Algorave programmer coerces SuperCollider's JITLib into an inevitably noisy landscape of deformed calculations and deviant beats.

A performance narrative is derived by searching twitter during the performance for tweets containing the words "algorithm" and "rave". Scanning collected tweets for commonly occurring words provides ad hoc and abstract performance directions and an artificial social commentary on the performer's genuinely antisocial code play.





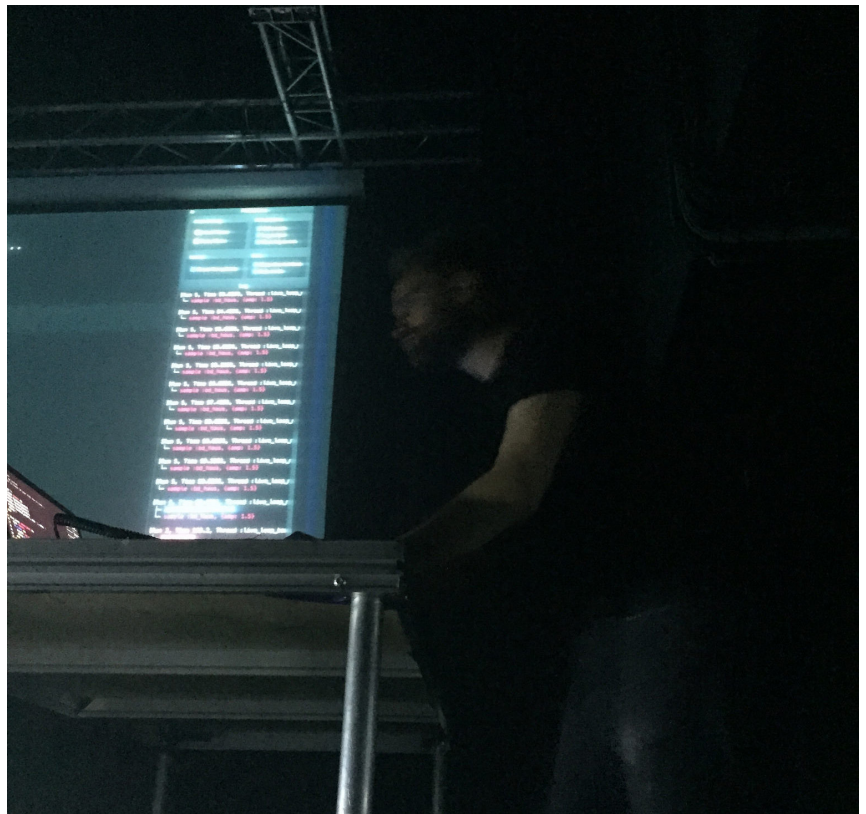
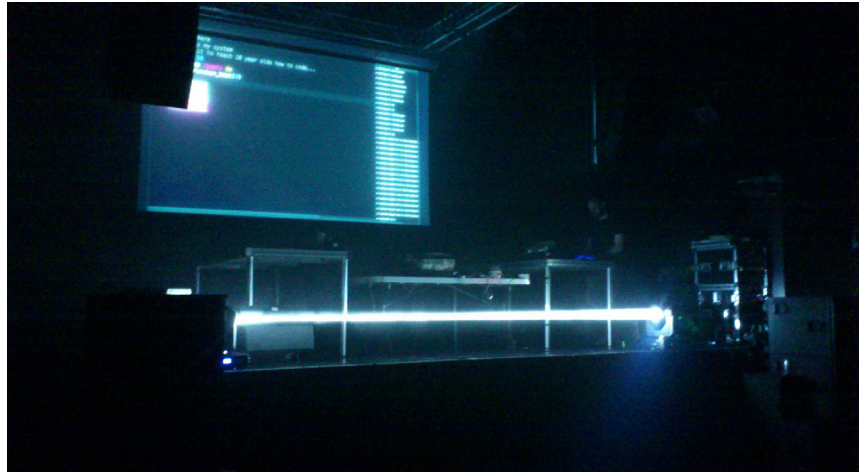
Algorave Performance



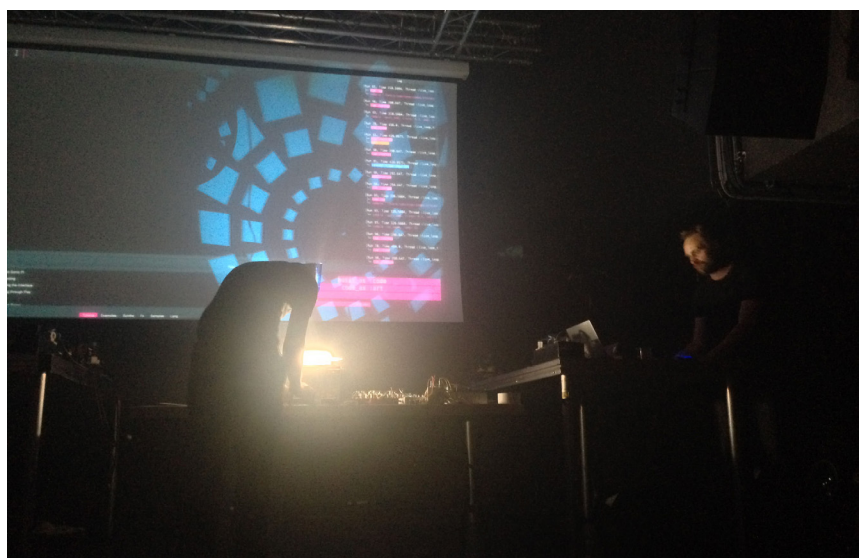
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Sam Aaron
University of Cambridge
samaaron@gmail.com

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Sam Aaron performing with
Christian Faubel's visuals





Keynote



Evolution Art and Computers Now

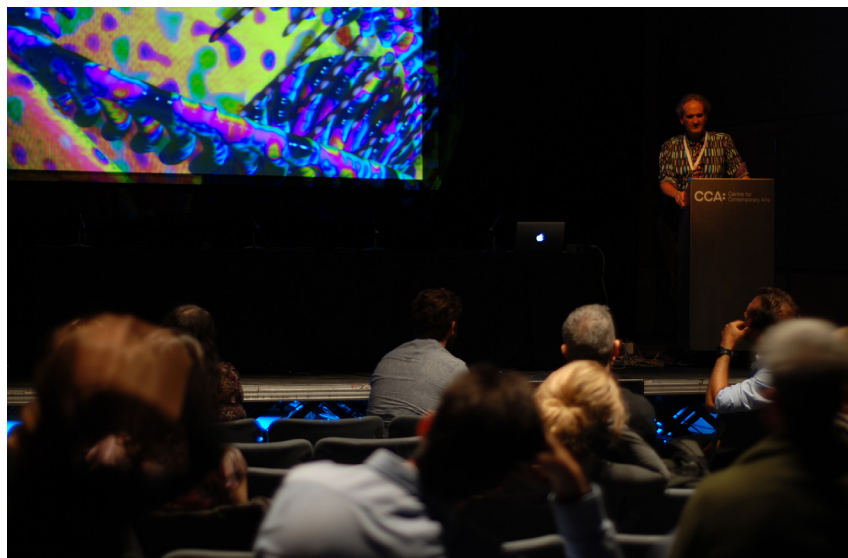


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William Latham
Goldsmiths, University of London
w.latham@gold.ac.uk

William Latham was one of the pioneering UK computer artists and rapidly gained international reputation in the 1980s. His work blends organic imagery and computer animation, using software modelled upon the processes of evolution to generate three-dimensional creations that resemble fantastical other-worldly forms such as ancient sea shells, contorted animal horns or organic alien spaceships. His latest exhibition *Mutator 1+2*, produced in collaboration with mathematician Stephen Todd, features interactive projections that blur the barriers between art and science.





Biographies



Sam Aaron

Sam Aaron is a live coder who considers programming as performance and strongly believes in the importance of emphasizing, exploring, and celebrating creativity within all aspects of programming.

Sam is also the creator of the music live coding environment Sonic Pi, a new musical instrument that uses code as its interface. Sonic Pi is both simple and powerful; simple enough to use to teach introductory programming and music within schools, yet powerful enough for professional artists to perform with in nightclubs. By day, Sam is a Postdoc Researcher at the University of Cambridge Computer Laboratory and by night he codes music for people to dance to.

<http://twitter.com/samaaron>

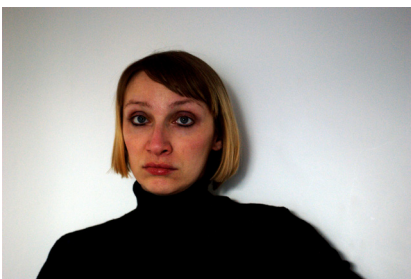
<http://facebook.com/livecodersamaaron>



Monty Adkins

Monty Adkins is a composer and performer of experimental electronic music. Since 2008, his compositions are characterised by slow shifting organic textures often derived from processed instrumental sounds. Exploring a post-acousmatic aesthetic, his music draws together elements from ambient, acousmatic and microsound music. His thinking is bound up in the notion of nodalism, a concept expounded in a recent published paper delivered at the xCoAx Conference, Portugal (2014). Prof. Adkins is also active as a writer and concert curator. His recent edited volume (with Prof. Michael Russ) on the music of Roberto Gerhard was the first scholarly edition produced on the composer's work and includes chapters on Gerhard's hitherto unknown electronic music. Adkins directed an AHRC project based at the University of Cambridge Library to recover and digitise Gerhard's electronic music. These works are published for the first time on CD/LP by sub rosa (Belgium).

www.montyadkins.wordpress.com



Gabriella Arrigoni

Gabriella Arrigoni is AHRC funded PhD candidate in Digital Media at Culture Lab (Newcastle University) where she is researching the notion of artistic prototype and exploring the relationship between art practice and labs. Former editor in chief on UnDo.net, the first Italian network for contemporary art, she has also published articles and essays on a number of magazines, catalogues and web-platforms. She has curated exhibitions, workshops and talks in galleries and not-for-profit spaces with a special focus on topics such as science, science-fiction and co-creation.



Paul Atkinson

Paul Atkinson is an industrial designer, design historian and educator with a PhD from the University of Huddersfield. He is currently Professor of Design and Design History at Sheffield Hallam University and has had articles published in a number of international design journals. He has authored two books on the design history of computers (*Computer*, Reaktion 2010, and *Delete: A design history of computer vapourware*, Bloomsbury 2013), and contributed a number of chapters to edited books. He has also written about the future of the design profession and examined the future impact of emerging technologies on the nature of design through practice-based research into Post Industrial Manufacturing.

www.paulatkinsondesign.com



Gilberto Bernardes

Gilberto Bernardes received a Master's in Music Performance from the Amsterdamse Hogeschool voor de Kunsten and the PhD in Digital Media from the University of Porto under the auspices of University of Texas at Austin. He was awarded the Fraunhofer Portugal Challenge 2014 prize for his PhD dissertation. Currently, he is a postdoctoral researcher at INESC TEC where he pursues work on automatic music generation and an Associate Professor at the Polytechnic Institute of Castelo Branco. Dr. Bernardes is active as saxophonist, new media artist, and researcher in sound and music computing.



Frédéric Bevilacqua

He is the head of the Sound Music Movement Interaction team at IRCAM. His research concerns the modelling and the design of interaction between movement and sound, and the development of gesture-based interactive systems. He holds a master degree in physics and a PhD in Biomedical Optics from EPFL in Lausanne. He also studied music at the Berklee College of Music in Boston and has participated in different music and media arts projects. In 2003 he joined IRCAM as a researcher on gesture analysis for music and performing arts.

ismm.ircam.fr/



Peter Beyls

Peter Beyls is an interdisciplinary artist developing generative systems in music, the visual arts and hybrid formats. Beyls studied at the Royal Music Conservatory Brussels, EMS Stockholm, Ghent University and the Slade School of Art, University College London. Current research interests include machine learning for interactive music systems and cognitive issues in software for art. Beyls holds a PhD in Computer Science from the University of Plymouth, UK and is currently a full time research professor at CITAR, Universidade Católica Portuguesa, Porto and visiting professor of Media Art at the School of Arts, University College Ghent.



Josh Booth

Josh Booth's work explores modes of disorientation / orientation through immersive, hyperactive sound and video. Both mediums exhibit various cultural allusions - from noise and deep bass music to glitch aesthetics, retro / low res gaming, and concrete cinema. His pieces have been performed and exhibited both internationally and in the U.S. Some notable events include (un)Scene Art Show (NYC), Mantis Festival (UK), Aperture Foundation (for Rinko Kawauchi's "Ametsuchi" exhibition) (NYC) and the Prague Quadrennial – Sound Kitchen (CZ). He has also worked as a coproducer/cowriter with the hip hop group dālek on Ipecac Recordings since 1998. He is currently a Ph.D candidate in composition at Rutgers University Mason Gross New Jersey, where he studied under Charles Wuorinen and teaches as a part- time lecturer.

www.youtube.com/channel/UCiVtT7MR9hOXgcFWTaHmijw

soundcloud.com/joshuaboorth-1



Victoria Bradbury

Victoria Bradbury @vbradbury is an artist weaving programming code, physical computing, body and object. She is completing her PhD research with CRUMB at the University of Sunderland, UK, and recently has implemented collaborative methods in forums such as workshops, art hacking events, and residencies. These include the IMMERSION: Art and Technology workshops (Shanghai, China, 2012) and Digital Media Labs (Barrow, UK, 2014). Bradbury recently co-organized the Thinking Digital Arts // Hack (Newcastle UK, 2014) and was a member of the British Council team for Hack the Space, Tate Modern. (London UK, 2014).

www.victoriabradbury.com



Marcelo Caetano

Marcelo Caetano received the Ph.D. degree in signal processing from Université Pierre et Marie Curie - Paris 6 in 2011 under the supervision of Xavier Rodet, head of the Analysis/Synthesis group at IRCAM. He was Marie Curie postdoctoral fellow with the Signal Processing Laboratory at FORTH in 2012-2013. Currently, he is postdoctoral fellow with the SMC group at INESC TEC and invited Assistant Professor at FEUP, University of Porto. Dr. Caetano's research interests range from musical instrument sounds to music modeling, including analysis/synthesis models for sound transformation and music information retrieval.



Pedro Cardoso

Pedro Cardoso is a designer, and a gamer. He is also a researcher at ID+, Research Institute on Design, Media and Culture. He has a BA and MA on Design and is currently a PhD student on Art and Design both at the University of Porto, pursuing studies in video games in the context of new media and interaction design, and developing experimental work in this scope. He is currently a guest lecturer in the Department of Design at the University of Porto, Portugal.

pcardoso.tumblr.com



Miguel Carvalhais

Miguel Carvalhais is a designer and a musician. He has a PhD on Art and Design, by the University of Porto, and is an Assistant Professor in the Department of Design of the University of Porto and a researcher at ID+, chiefly focusing on interaction design and computational media and arts. He collaborates with Pedro Tudela in the @c project, developing works in musical and audiovisual composition, music for theater, sound performances and installations. In 2003 he founded the Crónica media label, that he has been running since.

www.carvalhais.org



Alessio Chierico

Alessio Chierico is MA candidate of the Interface Culture department in the Art and Design University Linz. Former student of the art academies of Urbino, Carrara and NABA in Milan. His artistic research is based on the deconstruction of interfaces, looking for new naturalness formed by the essential properties of material and immaterial objects. A large part of his research focus on the aesthetics of digital representation. He had more than fifty exhibitions, including: ArteLaguna prize in Venice, Ars Electronica festival, Museu Nacional de Arte Contemporânea of Lisbon, Victoria Art gallery in Bucharest, Speculum Artium in Slovenia.

chierico.net



Ricardo Climent

Ricardo Climent is Professor of Interactive Music Composition at University of Manchester, UK, where he serves as director of the NOVARS Research Centre and as head of Composition. For the last few years his research has focused on the potential of game-audio, physics and graphic engines for compositional purposes, using 'the aural' as the primary source for navigation and exploration.

game-audio.org

electro-acoustic.com

www.novars.manchester.ac.uk



Stefanos Dimoulas

Stefanos Dimoulas was born in Volos, Greece in 1994. He joined the BA Modern Ballet course of the Royal Conservatoire of Scotland in 2012 as a full scholarship award student. Back in Greece he worked for Anti-thesis Dance and Theatre Company and was chosen to dance in the production of 'The Nutcracker' by Universal Ballet of Korea. Since he has been in Glasgow apart from having the lead male role in several dance videos, including 'Something in my heart' by Röyksopp, he was casted for one of the roles in Matthew Bourne's 'Lord of the flies' and was one of the two students who were chosen to travel to Singapore with Scottish Ballet for the Youth Cultural Exchange Project as part of the Commonwealth Games.

www.stefanosdimoulas.com



Christian Faubel

Christian Faubel works at the lab3 – the laboratory for experimental computer science at the Academy of Media Arts Cologne. Till 2012 he worked at the Institute for Neural Computation in Bochum, where he received his Ph.D in electrical engineering in 2009. In his work he is interested what it is that enables autonomous behavior? how complex autonomous behavior may result from the interaction of very simple units and from the dynamics of interaction between such units. he explores the assembly of simple units into systems and the emergence of autonomous behavior both in artistic and in scientific research.

interface.khm.de/index.php/people/lab3-staff/christian-faubel/



Emmanuel Flety

Emmanuel FLETY is a hardware engineer at IRCAM and part of the Music Movement interaction team (ISMM).

He designs sensor electronics and platforms for gestural captation and recognition along with digital connected objects.



Jules Françoise

Jules Françoise is a postdoctoral researcher in the {Sound Music Movement} Interaction team at Ircam, on the SkAT-VG european project. He holds a Master's Degree in Acoustics and a PhD in computer science from Université Pierre et Marie Curie, that he completed in the {Sound Music Movement} Interaction team at Ircam. His research interests intersect human-computer interaction and machine learning with a focus on expressive movement and its interactions with sound. He is interested in understanding and designing interactive systems exploring movement-sound interaction, with applications to performance, interactive sonification and rehabilitation.

julesfrancoise.com



Pete Furniss

A professional clarinetist for over 20 years, Pete's career has covered a broad spectrum of musical activities and interests, from concerts with orchestras and ensembles to free improvisation, arranging and conducting, education at all ages and standards, and more recently, solo performances with electronics. The emergence of 'electro-instrumental' or 'live electronic' practice since the 1960s has afforded significant augmentation to traditional acoustic instruments in terms of timbre, harmony, pitch range and spatiality. Pete's work explores the relationships between human presences, machine intervention and considerations of space in live electronic 'performance ecosystems', and asks questions about identity, agency and perception in music making as a whole.



Julien Groboz

Independent designer. He obtained his industrial creator diploma in 2012 from The ENSCI Les Ateliers with honors for « the research process », Paris, France. In his personal researches he explore different ways to approach uses and shapes by the experimentation of basic interactions with objects and motion principles. In 2014 he obtained the project assistance of the VIA for the Oo lamp that has been exhibited during the shows « Maison & Objet »(Villepintes, France) and « France Design »(studio più, Milano, Italy). In collaboration with the IRCAM institute, he participates to the Legos project that studies Sound-gesture relationships.

www.juliengroboz.fr



Rainer Groh

Prof. Dr.-Ing. habil. Rainer Groh is teaching media- and interaction design at the Technische Universität Dresden. His main research areas are the theory and methodology of interactive imagery and Visual Engineering. The interdisciplinary research addresses the rapid development of hardware and software systems by establishing novel kinds of interfaces between human and computer. The focus is on user and situation aware data visualization with the help of innovative technologies such as gestural interaction, autostereoscopy, and gaze tracking.

mg.inf.tu-dresden.de/mitarbeiter/rainer-groh



Thomas Gründer

Thomas Gründer is a research associate at the Technische Universität Dresden. He is working in the project DAMM, sponsored by the DFG. His main research topics include the Development, Evaluation and Methodology of user interfaces. One core research area is related to the interaction in augmented reality scenarios using gestures, gloves and wearables and the expressiveness of diversity human motion.

mg.inf.tu-dresden.de/mitarbeiter/thomas-gruender



Edwin van der Heide

Edwin van der Heide is an artist and researcher in the field of sound, space and interaction. He extends the terms composition and musical language into spatial, interactive and interdisciplinary directions. His work comprises installations, performances and environments. In his pieces, the audience members are placed in the middle of the work and challenged to actively explore, interact and relate themselves to the artwork. Besides running his own studio, he is a part-time Assistant Professor at Leiden University (Media Technology MSc programme) and heading the Spatial Interaction Lab at the ArtScience Interfaculty of the Royal Conservatoire and Royal Academy of Art in the Hague.

www.evdh.net



Rodrigo Hernández

Rodrigo Hernández-Ramírez was born in Mexico City in 1982. In 2006 he obtained a BA in social communications. After a few years working as a production and photography assistant, and as a web designer, he decided to pursue an MA in photography at the Faculty of Fine arts in Lisbon. Currently he is completing his Ph.D. dissertation at the same institution.

His primary research interests include media studies, photography, visual hermeneutics, philosophy of science and philosophy of technology.

His future research plans involve analysing the cultural impact of information technology and the influence of pragmatist discourses on current media analysis.



Olivier Houix

He obtained a PhD degree in acoustics in 2003 from the Université du Maine, Le Mans, France. His research interests concern the perception of environmental sounds and the gesture-sound relationship applied to sound design. He teaches sound practice at the superior school of Fine Arts TALM Le Mans and in the master of sound design. He is member of the Sound Design and Perception Team at Ircam, where he participated to national and European projects such as CLOSED. He participates to the Legos project that studies Sound-gesture relationships and to the Skat-VG european project (Sketching Auditorily with Vocalizations and Gestures).

pds.ircam.fr/864.html



Mark Hursty

Mark Hursty is a researcher at the National Glass Centre (NGC), University of Sunderland, UK. His project concerns reviving and reinterpreting pressed glass, a serial mass production technique, for sculptural use. He also combines interdisciplinary methods to create multimedia installations and performances, including Metabellum (2011). CAD/CAM is integral to Hursty's work, which uses digital fabrication to create elaborate moulds for pressing molten glass. He founded Hurstin Studio Glass and Metal in Plymouth, MA, USA (1999), and was Glass Program Head at Jacksonville University, USA (2008-10). Hursty is a Fulbright award recipient (Beijing, 2011) where he spent 16-months at Tsinghua University in. He continues to research, collaborate and teach within Universities and private studios in China.

www.markhursty.co.uk



Jung In Jung

Jung In Jung is a sound artist who has been collaborated with contemporary dancers considering how to present sound composition in interesting ways with interactivity. Jung is from South Korea, and was educated at London Metropolitan University where she specialised sound and media. She started using computer technology to create installations and performances while she was doing her master's degree at the University of Edinburgh. She has completed an artist in residency programme for one year in New York City in 2014, and returned to the UK to pursue her PhD in Music Technology at The University of Huddersfield.

www.junginjung.com



Paul Keir

Dr. Paul Keir is a lecturer in the School of Engineering and Computing at the University of the West of Scotland. Previously, Paul led the research and development group at Codeplay Software Ltd. in Edinburgh; with responsibility for Codeplay's 2 EU FP7 projects: LPGPU and CARP. Prior to that, Paul gained 10 years of professional experience developing video games and interactive graphical applications in both research and commercial environments. Paul has an M.Sc. in 3D Computer Graphics and an M.Sc. in High Performance Computing (HPC); and completed a Ph.D. in Computer Science at the University of Glasgow in 2012, on the topic of heterogeneous multicore compilers.



Damián Keller

Damián Keller (DMA Stanford University 2004; MFA Simon Fraser University 1999) is associate professor at the Federal University of Acre, Brazil, where he coordinates the Amazon Center for Music Research (NAP - Núcleo Amazônico de Pesquisa Musical). Member and cofounder of the Ubiquitous Music Group (g-ubimus), his research focuses on ecologically grounded creative practice and ubiquitous music. He coauthored the volumes *Ubiquitous Music* (Springer) and *Musical Creation and Technologies* (ANPPOM Press). His musical output features the application of ecompositional techniques in theater, film, electroacoustic and installation artworks.

ccrma.stanford.edu/~dkeller



Shelly Knotts

Shelly is a data-musician who performs live-coded and network music internationally, collaborating with computers and other humans. She has received several commissions and is currently part of Sound and Music's 'New Voices' emerging-composer development scheme. She is currently studying for a PhD with Nick Collins and Peter Manning at Durham University. Her research interests lie in the political practices implicit in collaborative network music performance and designing systems for group improvisation that impose particular (anti)social structures. As well as performing at numerous Algoraves and Live Coding events, current collaborative projects include network laptop bands BiLE and FLO (Female Laptop Orchestra), and live coding performance [Sisesta Pealkiri] with Alo Allik.

shellyknotts.co.uk/



Nicole Koltick

Nicole Koltick is an Assistant Professor in the Westphal College of Media Arts & Design at Drexel University and the founding Director of the Design Futures Lab where she leads a graduate research group in critical design practices investigating the intersection of artificial intelligence, robotics, ethics, design and aesthetics. Nicole writes extensively on the philosophical and theoretical implications concerning concepts of the “natural”, the “synthetic”, aesthetics, the rapidly evolving digital landscape and implications of emerging computational ecologies. She has recently completed papers on dark data, aesthetics of emergence, materiality and agency in the future and speculative realist approaches to design.

www.designfutureslab.com



Gordan Kreković

Gordan Kreković is a PhD student at the Faculty of Electrical Engineering and Computing, University of Zagreb. The focus of his research is on applying artificial intelligence techniques to sound synthesis in order to achieve an intuitive interface for controlling the sound synthesis process. Such an interface could help musicians to be more efficient and creative.

Outside the academic life, Gordan works as a manager in a software development company and spends his free time composing music and playing keyboards.



Linda Kronman

Linda Kronman is a media artist and designer from Helsinki, Finland currently living and working in Linz, Austria. In her artistic work she explores interactive and transmedial methods of storytelling with a special focus on digital fiction. In connection with her studies at the MediaArtHistories program in Danube University Krems, she explored participatory ways to experience and archive social media fiction. She is interested in participatory art and design practices, specially in connection to creative activism. She has organized several participatory workshops and attended international exhibitions including Moscow Young Arts Biennale, Siggraph ASIA, NEMAF and WRO Biennale, xCoAx.

www.kairus.org



Alessandro Ludovico

Alessandro Ludovico is an artist, media critic and chief editor of Neural magazine since 1993. He received his Ph.D. degree in English and Media from Anglia Ruskin University in Cambridge (UK). He has published and edited several books, and has lectured worldwide. He's one of the founders of Mag.Net (Electronic Cultural Publishers organisation). He also served as an advisor for the Documenta 12's Magazine Project. He teaches at the Academy of Art in Carrara. He is one of the authors of the Hacking Monopolism trilogy of artworks (Google Will Eat Itself, Amazon Noir, Face to Facebook).

neural.it



Dane Lukic

Dane Lukic is a Lecturer in Organisational Behaviour and a dancer/performer originally from Bosnia and Herzegovina and currently based in London. Dane combines his academic teaching and research with analysis in dance and improvised performance. He has performed with a number of UK and international dance companies and choreographers including RuthMills-Dance, Dance House, Tanztheater, Secret Garden Party and Creative Scotland. Dane is trained in contemporary dance with particular focus on contact improvisation. He is particularly interested in boundary space between different fields - between disciplines, between cultures, between styles of dance, between art forms and between dance and non-dance space.



Thor Magnusson

Thor Magnusson's background in philosophy and electronic music informs prolific work in performance, research and teaching. His work focuses on the impact digital technologies have on musical creativity and practice, explored through software development, composition and performance. Thor's research is underpinned by the philosophy of technology and cognitive science, exploring issues of embodiment and compositional constraints in digital musical systems. He is the co-founder of ixi audio (www.ixi-audio.net), and has developed audio software, systems of generative music composition, written computer music tutorials and created two musical live coding environments. Thor Magnusson lectures in Music and convenes the Music Technology programme at the University of Sussex.



Alex McLean

Alex McLean is a live coder and research fellow based in ICSRiM, School of Music, University of Leeds. His current projects include the AHRC Weaving Codes, Coding Weaves project with the Copenhagen Centre of Textile Research and FoAM Kernow, the AHRC Live Coding Research Network with the University of Sussex, and numerous performance collaborations including Slub (<http://slub.org>), Canute (<http://canute.lurk.org>) and Sound Choreographer <> Body Code (http://blog.sicchio.com/?page_id=350). He is active in the digital arts, co-organising Dorkbot in Sheffield and London, co-founding the TOPLAP and Algorave movements, chairing international conferences including on Live Interfaces and Live coding, and currently edits the Oxford Handbook on Algorithmic Music with Prof Roger Dean.

yaxu.org



Alena Mésárošová

Alena Mésárošová (architect) founder member of interdisciplinary art group Manusamo & Bzika (created by visual artist Manuel Ferrer Hernández and Alena Mésárošová) focused on the creation of interactive installations involving the use of Augmented Reality and 3D modelling. Started in 2006, the group has produced AR creative work for numerous festivals and projects in Slovakia, Italy, Spain and Portugal. Alena holds a degree in Engineer-Architecture (Inzinier architekt) at the Fakulta Umení, Technická Univerzita v Košiciach, Slovakia as well as the Bachelor (Bakalár) and is currently pursuing PhD at the Polytechnic University of Valencia. She has lectured at San Gregorio de Portoviejo University, Manabí. Ecuador.

manusamoandbzika.webs.com



Evandro Miletto

Evandro Manara Miletto is an Associate Professor at the Federal Institute of Education, Science and Technology of Rio Grande do Sul (IFRS), Porto Alegre Campus, Brazil, where he is the leader of the Applied Computing Research Group. Since 2002 he has conducted multidisciplinary research on topics such as Computer Music, HCI, and CSCW. He is a member of the technical committee of Brazilian Symposium on Computer Music (SBCM) as well as the Brazilian Symposium on Computers in Education (SBIE). His research is currently based on networked music interactions focused on novice users.



Nicolas Misdariis

He is a research fellow and the co-head of Ircam / Sound Perception and Design team. He is graduated from an engineering school specialized in mechanics (CESTI-SupMeca); he got his PhD at CNAM (Paris) on the following topic: synthesis/reproduction/perception of musical and environmental sounds. In 1999, he contributed to the constitution of the Ircam / Sound Design team where he has mainly developed works related to sound synthesis, diffusion technologies, environmental sound and soundscape perception, auditory display or interactive sonification. Since 2010, he is also a lecturer within the Master of Sound Design in the Fine Arts school at Le Mans.

pds.ircam.fr/862.html



Mathias Müller

Mathias Müller is a research associate at the Technische Universität Dresden. Within the research project StereoAge, sponsored by the German Federal Ministry of Education and Research, he is working user-centered design of stereoscopic visualizations. Additional research area include gesture-based and tangible interaction in virtual environments. The focus is on unrevealed potentials of real-time computer graphics and novel tracking technologies to improve the user experience of interactive 3D visualizations by utilizing concepts from art and photography for innovative visualization techniques and psycho-physiological principles to adapt the machine to the needs and abilities of human beings.

mg.inf.tu-dresden.de/mitarbeiter/dipl-medieninf-mathias-müller



Nuno Otero

Nuno Otero is a Senior lecturer at CeLeKT and is interested in theories and conceptual frameworks in HCI, from more traditional approaches taking a user centred perspective to more recent trends focusing on user's experiences with technologies. In a nutshell, the question driving my research concerns the understanding of how the properties of distinct devices, computational artefacts and embedded external representations impact on people's activities (from work related activities to educational and ludic contexts). Furthermore, he is also keen on understanding how distinct methodologies suit the investigation of different issues along the artefact design cycle and how the design solutions can be documented and reused by design teams.



Mark Pilkington

Mark Pilkington is a composer and performer of electroacoustic music. His practice encapsulates both sound and image as a means to extend spatial imaginings between real and virtual space. The coupling of sound and image are applied to electroacoustic music, site-specific installation and screen-based works. Forging immaterial and creative labor through a network of interwoven and augmented territories, his work increasingly queries the way operations carry great critical and creative potential. Seeking new modes of critical engagement that incorporate multiple narratives through non-digital and digital aesthetic informs the direction of his pedagogy. His theoretical research focuses on the relationship between artistic genres and their respective aesthetic theories with reference to: electroacoustic music, sound synthesis, visual music, coding, philosophy, and film. His practice specially focuses on audio-visual composition using real and virtual entities as a means to explore time and space. His work have been performed, exhibited and screened at conferences and festivals throughout the UK and Europe. Collaborative interdisciplinary work is carried out with composes and visual artist/s. His work has been performed and screened at ICMC, ARS Electronica, MANTIS festival and Open Circuit Festival.



Raul Pinto

Born in 1978, in South Africa, studied in Portugal and opened his own design studio focused on interior and product design (Aveiro Meu Amor) after graduating in Product Design (ARCA-EUAC). In 2009 received his M.Sc. in Engineering Design (IST) and in 2011 the title of Specialist in Product Design (IPG; IPL; IPVC). Working as a lecturer since 2010: IPG, IPV, UA and at the moment at the department of Industrial Design of the faculty of Fine Artes and Design in the Izmir University of Economics, he is currently a PhD candidate at the University of Aveiro where he is studding and working with biological generative systems, looking for alternative production tools aimed at customization.

www.paulatkinsondesign.com



Renate Pittroff

Renate Pittroff works as a freelance director in the areas of experimental theater and acoustic art (audio drama, radio art, sound installation). She is a lecturer at the Department of Theatre, Film and Media Studies, University of Vienna. Since 1995, she designed and directed the projects of “theaterverein meyerhold unltd.” In the areas of radio plays and acoustic art she works primarily with Austrian authors like Friederike Mayröcker, Peter Rosei, Franz Schuh, Brigitta Falkner and Lisa Spalt. In recent years, she presented some art projects that deal with interactive methods. The result was “finalbluten” an interactive radio sound installation or projects “bm dna: Ministry of DNA Hygiene, Department: Hair - a theatrical usurpation”, “Tracker Dog” and “Samenschleuder”, last: “Re-Entry - life in the Petri dish. Opera for Oldenburg” 2010.

www.wechsel-strom.net



Antonio Pošćić

Antonio Pošćić is a PhD student at the Faculty of Electrical Engineering and Computing, University of Zagreb and working as a software engineer and team lead at Enghouse Interactive.

His research interests include innovative techniques within the field of specialized visual programming languages for artistic applications, especially sound synthesis and music creation. Motivated by the love of experimental and avant-garde musical forms, the aim of both his academic research and music criticism hobby is to help better understand and improve the link between technology and art.



André Rangel

Dilettant, Intermedia Artist/Designer, founder and art director of 3kta project since 2003. Develops compositional structures between media. His research interests range from computable algorithms and geometry to semiotics and philosophy. Holds a PhD in Interactive Art, a MA in Digital Arts and a degree in Communication Design. He is guest assistant professor at Faculty of Fine Arts of the University of Porto and regularly lectures at Portuguese Catholic University where he was researcher at CITAR — Research Centre for Science and Technology of the Arts..

3kta.net

www.i2ads.org/nai/author/amacedo/



Shamik Ray

Shamik is an interaction designer with a focus on creating tools that let people express, create and communicate better. He is currently based in London, UK where he is helping Barclays design future experiences around money. Having dabbled in music, photography, computer programming and startups, he loves projects where these passions collide. He is a graduate of the Copenhagen Institute of Interaction Design and believes in designing not only 'for' people but 'with' them, putting a lot of emphasis on prototyping from an early stage. His favourite materials are paper and wood and off late code and electronics.

cargocollective.com/shamik



Helen E. Richardson

Helen E. Richardson, Director, Performance and Interactive Media Arts MFA, Brooklyn College, <http://wp.pima-mfa.info>. Creative work focuses on collaborative creation and social engagement. Formerly Artistic Director of the Stalhouderij Theatre Company, Amsterdam, an international ensemble creating new works, and recognized for best productions of the year in the Netherlands on themes exploring the encounter between the 'old' and 'new' world, women's rights, and economic disparity. Founding member, co-curator, producer and dramaturg, Global Theatre Ensemble's theatre project on Eliminating Violence Against Women, commissioned by the United Nations. Author of various chapters on the collaborative practices of the Théâtre du Soleil published by Routledge.



Matt Roberts

Matt Roberts is a new media artist specializing in real-time video performance and new media applications. His work has been featured internationally and nationally, including shows in Taiwan, Brazil, Canada, Argentina, Italy, Mexico and nationally in New York, San Francisco, Miami, and Chicago. He has shown in several new media festivals including FILE, Zero1, 404, CONFLUX, and he recently received the Transitio award from the Transitio_MX Festival in Mexico City. He is the founder of EMP: Electronic Mobile Performance, and an Associate Professor of Digital Art at Stetson University.

mattroberts.info



Sofia Romualdo

Sofia Romualdo is a museologist, curator and researcher on the topic of videogames as an art form. She has a Master's degree in Museology and Curatorial Studies from the University of Porto, with a dissertation titled "Play, Games and Gamification in Contemporary Art Museums". She completed a year-long curatorial internship at the Serralves Museum of Contemporary Art (Portugal), where she worked on the exhibition "Monir Shahroudy Farmanfarman: Infinite Possibility. Mirror Works and Drawings 1974-2014". She currently works as a museologist, writer and project assistant for the permanent exhibition project at Casa da Memória in Guimarães (Portugal), due to open in late 2015.

thecuriouscurator.com/



Tom Schofield

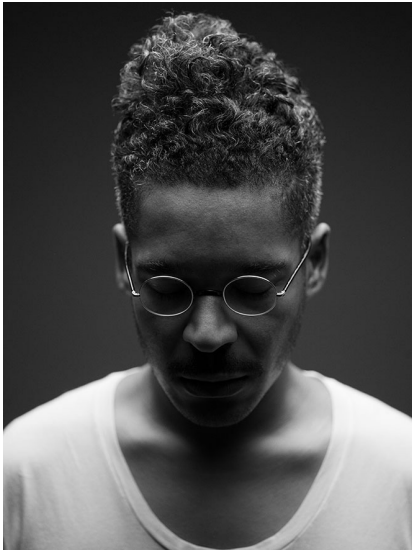
Tom Schofield is an artist, designer and researcher based at Culture Lab, Newcastle, UK. His practice-based research spreads across creative digital media, archives and collections interface design / visualisation and physical computing. His PhD thesis explored the role of technological materiality in developing works of art and design as part of ecologies of experience. Recent creative projects include Measure (with John Bowers) an interactive installation which combines 19th C pseudo-science with contemporary face tracking technology (<http://tomschofieldart.com/measure-with-john-bowers>), Neurotic Armageddon Indicator, a wall clock for the end of the world (<http://tomschofieldart.com/Neurotic-Armageddon-Indicator>) and 'null by morse', an installation with vintage military equipment and iPhones (tomschofieldart.com/null-by-morse).



Hanna Schraffenberger

Hanna Schraffenberger is a PhD candidate and researcher at the Media Technology Research Group at Leiden University. Her research interests include human-computer interaction, interactive art and augmented reality (AR). Her PhD research examines the fundamental characteristics and potential manifestations of AR. In particular, her research explores those unique AR scenarios and experiences that have no equivalent in a purely physical world. Besides doing research, Hanna is interested in communicating scientific topics to a broader public.

www.creativecode.org



Laurent Segretier

Laurent Segretier was born in 1978 in Guadeloupe in the French Caribbean, and currently splits his time between Hong Kong and Paris. He is responsible for some of the most radical and affecting work currently being produced. During his studies at business school in France he was an active member of his school's multimedia club, as well as a young filmmaker and electronics geek working in after-sale computer shops. Always fascinated with Asia, he moved to Beijing after graduation, and has been established in Hong Kong for eight years. Despite the possibility of a career in finance, he followed his passion by working as first assistant to one of the greatest photographers in Asia, Wing Shya. He has found a balance between Asia, where he was led by memories of the pop culture of his childhood, and Paris, where he connects with the masters of the history of modern art.

www.segretier.com



Emilia Sosnowska

Emilia Sosnowska is a freelance curator and media researcher with particular interest in emerging technologies and their impact on creative practices. She is currently undertaking her interdisciplinary PhD at the University of the West of Scotland. Her main research interest concerns multi-sensory experience in digital art. MA in Culture Theory - Wroclaw University, Poland, 2004. MFA in Visual Culture - Edinburgh College of Art/Edinburgh University, 2010. Ph.D. Candidate: New Media Arts and Creative use of Technology – University of the West of Scotland.



Luke Sturgeon

Luke Sturgeon is a London based designer and researcher who works in the area between science, technology and humanity. His work provides new perspectives on technological research and development through the investigation of contemporary culture in relation to emerging technologies. He often use utilises existing or generated data and recorded media to create digital prototypes, installations, fictional narratives, hyperrealities, and speculative design proposals that provoke individual and social reflection and critical discussion. He is a 2013 Alumni from the Copenhagen Institute of Interaction Design (CIID) as well as currently pursuing an MA in Design Interactions from Royal College of Art.

lukesturgeon.co.uk



Patrick Susini

Patrick Susini received a PhD degree and a Habilitation in Psychoacoustics. He is the head of the Sound Perception and Design group at IRCAM. His activities include research on loudness and everyday sound perception, and applications in sound design. He has coordinated several industrial, national (ANR) and European (FP7) projects. He teaches psychoacoustics, psychophysics, and sound design.

pds.ircam.fr/861.html



Christoph Theiler

Christoph Theiler (1959/BRD) lives in Vienna since 1982. Working as freelance composer and media artist. His last works are established in the area multimedia and sound installation. GATE II+III are the works, in which new forms of interactive sound design were developed. As in the case of MEMBRAN II (for e-guitar, sax and medium wave transmitters), M.O. - HERZ + MUND (sound installation with 3 bass loudspeakers and very low frequency waves) and HF 114 (electronic composition for 7 transmitters) more and more means from the area of the electronic music, the sound design, the high-frequency engineering and the internet are included in his artistic conception. The electronic composition NEARNESS was published on the "Sonic Circuit" festival CD 2001. He got the composition price of the city of Stuttgart (1982) and the composition price "Luis de Narvâez" Granada (1993) for the 1st and 2nd string quartet. Recordings made by WDR, ORF, Deutschlandradio, radio Koper, Ljubljana-TV and BR? Compositions for chamber ensemble, orchestra, electronics, theatre and radio play.

www.wechsel-strom.net



Brad Tober

Brad Tober, an Assistant Professor of Graphic Design at the University of Illinois at Urbana-Champaign (USA), is a designer, educator, and researcher whose work explores the potential of emerging code-based and interactive visual communication technologies, with the objective of identifying and investigating their relationships to design practice and pedagogy. His practice-led research entity, the Experimental Interface Lab, is characterized by a speculative approach to design (a manifestation of pure research) that recognizes that forms of and methodologies for contemporary practice that spans design and technology are best developed through fundamentally flexible and exploratory processes. Brad holds an MDes from York University (Toronto, Canada), a BFA in graphic design from the Savannah College of Art and Design (USA), and a BA in mathematics from the University at Buffalo (USA).

bradtober.com/

experimentalinterfacelab.org/



Graeme Truslove

Graeme Truslove is a composer and performer based in Glasgow, Scotland. His output includes: sonic and audio-visual compositions, and improvised music – playing guitar and/or laptop in various solo and collaborative projects. His work is largely concerned with conflicts between intuitive performance and the fixed-medium, often integrating microtemporal and immersive approaches to sound creation and performance. Truslove has performed and exhibited his work internationally, and has attracted awards from: Metamorphoses (1st prize), The Salford Sonic Research Commission, Creative Scotland, The British Council, PRSF, The Dewar Arts Award and others. He holds both an M.Eng in Electronics with Music, and a Ph.D. in Music Composition from the University of Glasgow. He currently lectures in Composition and Music Technology at the University of the West of Scotland.

www.graemetruslove.com

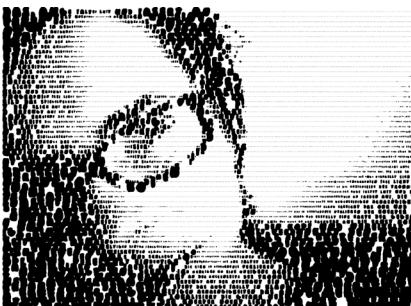


Katharina Vones

Originally from Cologne, Germany, Katharina Vones completed her BA(Hons) in Design and Applied Arts at the Edinburgh College of Art in 2006, and gained an MA RCA from the Royal College of Art, London, in 2010. She subsequently established her practice as an independent jewellery artist and researcher in the Scottish capital of Edinburgh, and as such has exhibited and presented her work widely both nationally and internationally. She is currently in the final year of her PhD at the University of Dundee, where she investigates the use of smart materials and microelectronics in the creation of stimulus-responsive jewellery.

www.smart-jewellery.com

www.kvones.com



Astrid Wegner

Astrid Wegner (*1984) studied Literature, Media Studies, Sociology and Cultural Studies in Marburg, Mainz and Hagen. She is currently exploring semi-automatic, half-conscious and intertextual forms of writing – looking for narratives that are genuine and reasonable in an attempt to merge different carriers of meaning. She is particularly interested in text forms that encourage active perception and can be adapted to work with audiovisual systems. She lives and works in Freiburg, Germany.



Ephraim Wegner

Ephraim Wegner (*1980) studied audiovisual media at KHM in Cologne and is currently teaching generative art and audiovisual media at the university in Offenburg. As an artist he uses various computer languages (like Csound, Pure Data and Processing) to combine different forms of digital audio synthesis and generative art, “steering” towards multidisciplinary approaches and concepts. His performance practice ranges from improvisation (preferably using live input from instrumentalists) and notated works up to algorithmic compositions. Up to now there were numerous cooperations with other musicians, ensembles, festivals and institutions, among others ZKM (Karlsruhe), “ars acustica” (SWR2), “Acht Brücken Festival” (Cologne) and „Donaueschinger Musiktage“. In 2015 he received a scholarship from Kunststiftung Baden-Württemberg.



Terri Witek

Terri Witek is the author of *Exit Island*, *The Shipwreck Dress* (both Florida Book Award Medalists), *Carnal World*, *Fools and Crows*, *Courting Couples* (Winner of the 2000 Center for Book Arts Contest) and *Robert Lowell and LIFE STUDIES: Revising the Self*, as well as a recent comic book/ poetry chapzine, *First Shot at Fort Sumter/Possum*. Her poetry has appeared in *Slate*, *The Hudson Review*, *The New Republic*, *The American Poetry Review*, and other journals, and she is the recipient of fellowships from the MacDowell Colony, Hawthornden International Writers’ Retreat, and the state of Florida. A native of northern Ohio, she teaches English at Stetson University, where she holds the Sullivan Chair in Creative Writing.

terriwitek.com



James Wyness

James Wyness is a composer with an interest in abstracting sounds from their generators, examining the morphological features of complex sounds in accordance with their inherent materiality, observing and structuring the birth and evolution of these forms as they unfold and in directing this complexity into music. He has an MA Honours degree in French Studies and a PhD in electroacoustic composition from the University of Aberdeen. Current research interests include semiology, anthropology, the origins of language and the history of language development, sociolinguistics, social theory, cultural theory and the political economy of the arts, morphology, determinism/randomness, set theory, topology, dynamic systems and evolutionary biology.



Martin Zeilinger

Martin Zeilinger holds a PhD in Comparative Literature from the Univ of Toronto and is a researcher, curator, and practitioner in the areas of media studies and media theory, focusing on contemporary art, games, and intellectual property issues. He is also co-director of the Toronto-based Vector Game Art & New Media Festival. Having performed with the Vienna-based improv rock band Thalija for many years, recently he has begun a solo practice live coding in Sonic Pi.

marjz.net/



Andreas Zingerle

Andreas Zingerle is a media artist from Austria. He is a PhD candidate at the Timebased and Interactive Media Department in Linz (Austria). He is researching vigilante online communities of scammers and anti-scam activists and implements their mechanics in interactive narratives and creative media workshops. In the last years he worked on several installations exploring a creative misuse of technology and alternative ways of Human Computer Interaction. Since 2004 he takes part in international conferences and exhibitions, among others Ars Electronica Campus, Siggraph, Japan Media Arts Festival, File, WRO Biennale, Steirischer Herbst, xCoAx.

www.andreaszingerle.com

www.kairus.org

This project is partially funded by FEDER through the Operational Competitiveness Program – COMPETE – and by national funds through the Foundation for Science and Technology – FCT – in the scope of projects PEst-C/EAT/UI4057/2011 (FCOMP-OI-0124-FEDER-D22700) and PEst-OE/EAT/UI0622/2014.



